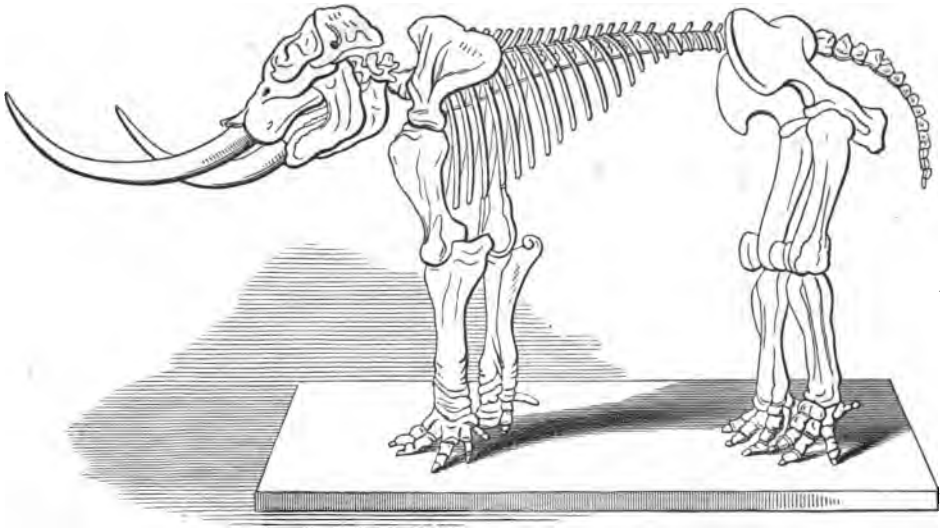
Miss Nellie A. Rice

Worcester

Mass

April 2nd 1862.

Geology is the world's autobiography



Skeleton of the Mastodon Ohioticus (North America).
Height, nine and a half feet; length, twenty feet.

A

FAMILIAR COMPEND

OF

GEOLOGY.

For the School and Family.

BY

A. M. HILLSIDE.

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INTRODUCTION.

THIS work was originally prepared for my own children, and, though considerably enlarged, is still, what I intended it to be, an elementary work, fitted for the recitation of a class; which is not the case with the majority of the delightful geological treatises that have been presented to the public by various distinguished geologists. Even the few which have been intended for text-books, are either too complex and voluminous, for the degree of attention which our modern system of education will allow to any one science, or they are open to the same objection as the larger works just spoken of—they are treatises rather than text-books.

Geology has fought her battle, and nobly has she been defended by noble men, her day of triumph has more than dawned, and the sincere but mistaken Christians, who have opposed her, are now joining her ranks, to advance with her to new conquests, over the false philosophy which could hope to make God's word and works oppose each other. Like her sister, astronomy, she was accused of heresy, but even better than astronomy will she sustain true faith. The young astronomer having vainly striven, telescope in hand, to penetrate the mystic depths of the Universe, fills his mind with the figures which indicate those wondrous spaces, and bids Imagination set out to explore; but even Imagination tires ere she reaches the nearest star, and returning with weary pinion, sadly whispers to

her earthly master: "This knowledge is too wondrous, this God too great; less than the dust in the balance are we, how hopeless the lot of such utterly insignificant beings!" We may bid the drooping soul turn to the wonders of the microscope, and see human imagination as much baffled by minuteness as by immensity; but the perversity of an intellect unwilling to be convinced, the feebleness which cannot conceive One not like unto itself, answers, Yes, I admit the range of that wondrous Creative Power; but the more you increase the range, the stronger the presumption that a system has been instituted, and that all things work by fixed laws, originally impressed and then left to act. They cannot realize that "the Lord, the Creator of the ends of the earth, *fainteth not, neither is weary.*" Here Geology steps forward and says, Tread with me the backward path of creation, let me show you an abyss of ages equally unappreciable by human intellect as the abyss of space which has shaken your faith to its foundation; and we will turn page by page the records, we shall find on our pathway, which will prove to you that you are under the control of no system acting through necessity. A system there is, and always has been, proving its Author to be One who never changeth; One who seeth all things from the beginning; but differences, changes, adaptations, here, a bringing forward, there a holding back, are met with, that prove entire exemption from necessity—constant, intelligent, overruling superintendence. If by the examination of this record the idea is irresistibly impressed upon you, that all these changes, through untold ages of time, steadily fitted the globe for its present occupants, and evince a oneness of design from beginning to end, indicating one and the same ruler, always regulating both great and small concerns, will you not cease from the idle humility which would "compliment the Creator out of His own domains;" as if it were unworthy His greatness to do more than create, and then, like a child with its soap bubbles, cast off His creations to chance or

nature. Verily His ideas of greatness are as different from ours as His powers transcend our feeble faculties.

It seems a remarkable coincidence that the same period that has seen the monuments of Egypt unclose their lips, mute for thousands of years, and, in hieroglyphic language, confirm the truth of God's written word; which has witnessed old Assyria rise from her sandy tumuli, and bear the same testimony; has also, in God's kind providence, been marked by the successful investigations of science into the records of His own monuments, entombed long ere Egypt or Assyria began; which prove so clearly the value the great Creator sets on the being created in His own image, by the care He has taken to prepare for his reception, that His watchful love and wondrous interference in his spiritual behalf seem but parts of one great whole. With such views of the value of the science, in reference to its bearing on religion, as well as a keen appreciation of the pleasure to be found in its pursuit, I feel great regret it has not yet assumed the place it merits in our customary courses of education. This is, perhaps, in a great degree owing to the want of suitable rudimentary books; and, in the hope that this work may in some degree supply the want, I have taken great pains to render it as accurate as possible; and, tying myself down to an almost wearisome brevity, have endeavored to compress as many facts as practicable in a small space, that if I lay but the foundation it may at least be well laid. I have made no references to authorities through the work, as it is only designed for learners, and I thought such references would needlessly encumber the pages, but I have consulted the works of nearly all the distinguished geologists of the day, and where it was necessary to bring in a controverted point, have presented it as held by the most reliable, and as illustrated by the most recent discoveries. Wishing to render the body of the work as concise as possible, that where a class had but a very short time to devote to the study, they yet

might obtain a view of the whole system of the science, I have thrown into the Glossary much information, which, whenever time permits, should be committed to memory as carefully as the catechetical part. I have avoided technical terms as far as possible, only introducing those which form the nomenclature of the science, or would be indispensable to the clear understanding of geological works and lectures. In offering this little book to the teachers of our country, I trust it having come from a female pen will not militate against it, when the works of a Somerville and a Bouvier are accepted as standards; and that the young will not receive ungraciously what originated in a mother's love.

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GEOLOGY.

CHAPTER I.

STRUCTURE OF THE EARTH.

Q. What is Geology?

A. The science which treats of the structure of the earth, with the plants and animals of past ages.

Q. What do we mean by the earth?

A. The world which we inhabit. It is the third planet from the sun, around which it revolves once a year, and is distant from it about 95,000,000 miles.

Q. What is the shape of the earth?

A. An oblate spheroid: that is a round ball, somewhat flattened at two sides.

Q. What part of our globe is thus flattened?

A. At the extreme north and south, called the poles; because the earth revolves, as if on an axis passing through it and coming out at those points.

Q. What is the size of the earth?

A. Its diameter is 7926 miles at the equator, where the globe is largest, and 7899 miles at the poles, where it is flattened; the difference is rather less than 27 miles. This departure from a true circle is so small that it could not be perceived by the eye in the largest sized model that could be constructed.

Q. What is the density of the earth?

A. Five and a half times that of water. That is, it weighs five and a half times more than a globe of water of the same size. This is more than twice the density of the most prevalent rocks at the surface.

Q. At what depth does air become as dense as water?

A. At thirty-four miles.

Q. At what depth does water become as heavy as quicksilver?

A. At three hundred and sixty-two miles. At the centre of the globe steel would be compressed to one-fourth, and common stones to one-eighth of the size they have at the surface.

Q. Does the actual weight of the globe correspond with these calculations?

A. By no means; it is much lighter than they would make it.

Q. How is this accounted for?

A. Either the materials which compose the centre of the earth are different from those of the surface, or some counteracting influence prevents the great compression which would naturally result from their position.

Q. How are changes in temperature produced upon the surface of the globe?

A. By variations of latitude and elevation, and by the nature of the soil and the distribution of land and water.

Q. To what depth does the heat of the sun penetrate?

A. Rarely beyond seventy feet.

Q. Below this depth, at what rate does the internal heat of the earth increase?

A. One degree for thirty feet, to one degree for seventy feet, according to the nature of the rocks.

Q. What is the mean height of the solid portion of the earth above the sea?

A. One thousand feet.

Q. Do any lakes or seas lie below the level of the ocean?

A. The Caspian and Aral seas, the Lake of Tiberias, the Dead Sea, and others.

Q. What is the mean depth of the ocean?

A. According to Humboldt, one thousand feet.

Q. What is the proportion of land and water?

A. Nearly three-fourths of the surface of the globe are under water.

Q. What is meant by the crust of the earth?

A. The exterior portion of it, accessible to man only a few miles. This crust is generally believed to be the only solid part of the globe; its thickness is variously rated by geologists, some think it does not exceed ten miles, others rate it as high as forty or fifty. In comparison with the diameter of the globe, these variations may be compared to those of different thicknesses of gold leaf with which an orange might be coated.

Q. What are the means by which we are enabled to examine this crust, the only portion of the earth of which we have any positive knowledge?

A. The displacing and throwing to the surface the different layers of the rocks, by volcanic and other agencies, have exposed them to our observations.

CHAPTER II.

AGENCIES.

Q. What are the agencies which produce geological changes?

A. Atmospheric, aqueous, igneous, and organic.

Q. How do atmospheric agencies act?

A. Both chemically and mechanically. Chemically, by the union of the oxygen and carbonic acid of the air with the different minerals, causing them to crumble and disintegrate; and, mechanically, by winds and frost.

Q. What is the name given to the mass of fragments which collects at the base of cliffs?

A. Talus; usually presenting a slope of forty degrees.

Q. How do aqueous agencies act?

A. Chemically, by dissolving and decomposing rocks; mechanically, by wearing them away and removing their particles.

Q. What effect is produced by the fragments of rocks, called moraines, in the glaciers?

A. The rocks over which the glaciers pass are scratched by them into parallel striæ (small channels) and grooves.

Q. What are the peculiarities of igneous agencies?

A. While air and water constantly wear away the inequalities of the earth's surface, the igneous agencies are constantly renewing them.

Q. In what way do the igneous agencies exhibit themselves?

A. In volcanoes, earthquakes, hot springs, and gradual elevations.

Q. What is the number of active volcanoes?

A. About three hundred; two-thirds of these are on islands.

Q. What is the greatest eruption of modern times, in respect to the quantity of lava discharged?

A. Skaptaa Jokul, in Iceland, in 1783. (See note *a*.)

Q. What the most violent and destructive?

A. That which took place in 1815 in Sumbawa, one of the Sunda group of islands. It was heard for nearly 1000 miles, and destroyed upwards of 12,000 people. (See note *b*.)

Q. Though organic agencies are the least active, they are the most interesting. How do they act?

A. Vegetable organisms, by their decay under different circumstances, form soil, peat, and coal. Immense masses of rock are formed by the remains of animalculæ and shells. No single organism can compete with the coral polyps in changing the earth's surface; numberless islands have been produced by them, and reefs, varying in length from a few feet to over a thousand miles.

Q. What is the meaning of the term rock in Geology?

A. Any mineral masses, either hard or soft, compact or loose. The Sahara desert is a sand rock; masses of clay and gravel are called rocks.

Q. How are rocks divided?

A. Into stratified and unstratified.

Q. What causes the stratification of rocks?

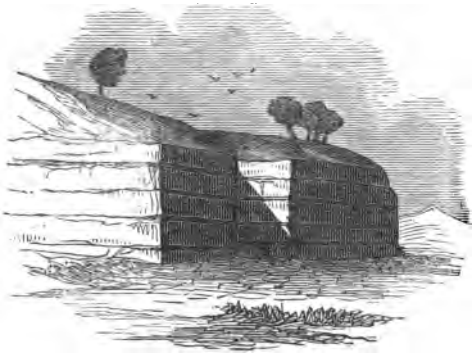
A. The settling of particles in water. Stratified rocks are also termed aqueous and sedimentary. Most of them exhibit ripple marks.

Q. What mineralogical names have been given to stratified rocks?

A. The Sand Group, Clay Group, and Lime Group,

which are termed arenaceous, argillaceous, or calcareous, as sand, clay, or lime prevail.

Fig. 1.



Q. What is the appearance of a stratified rock?

A. A stratified rock is one that may be described as having its upper and lower surfaces parallel to each other (fig. 1). It is composed of different strata, or layers, deposited at different times, one over the other.

Q. How are strata deposited?

A. Horizontally; according to the well known law by which all fluid substances find their level.

Q. Do the strata retain their horizontal position?

A. Very seldom. Most strata have been thrown up by volcanic action to a greater or less angle, some even to the perpendicular.

Q. Do stratified rocks occur in a regular order of succession?

A. The succession is always regular, but seldom unbroken.

Q. Give an illustration.

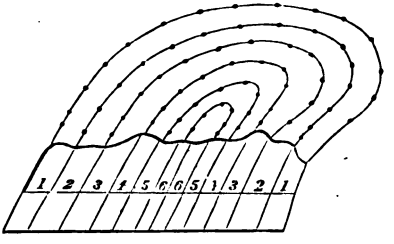
A. If a succession of beds or strata, deposited at different epochs, occur in one place, to which we apply numbers to designate them, in another place it may happen that some of these strata may be wanting; but those

found will occupy their respective places, no low number ever overlying a higher.

Q. Is this regularity of relative place invariable?

A. It is; though appearances may frequently deceive an inexperienced observer, as strata are sometimes folded over in such a manner (fig. 2) that when the upper part of the elevation is worn off the layers are presented inversely.

Fig. 2.



Q. Is this frequent?

A. In mountainous countries it is of frequent occurrence, sometimes one fold succeeding another for many miles.

Q. How is this explained?

A. By the upheaval of the igneous rocks, which push aside as well as elevate the layers through which they force themselves (fig. 3). This folding of strata may also be caused by the settling of some parts from shrinkage or internal cavities, as well as by the upheavals described. Strata thus bent and twisted are called *contorted strata.*

Fig. 3.

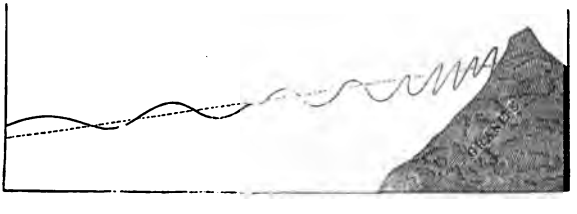
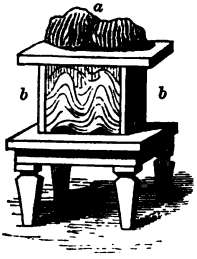


Fig. 4.



Q. Has this been illustrated by experiments?

A. Yes; layers of clay were put under a weight, and then subjected to lateral (side) pressure. The result was just such curves and elevations as we see in the displaced strata of mountainous regions. Any one can repeat the experiment with layers of different colored cloths and some books (fig. 4).

Q. Are vertical strata parts of such curves?

A. Yes; vertical strata have invariably been found to be the ascending or descending portions of a curve, sometimes with a diameter of a few feet only, sometimes of several miles.

CHAPTER III.

STRATA—TECHNICAL TERMS.

Q. What is meant by the dip of strata?

A. The dip of a rock is the angle formed by the plane of its strata with the plane of the horizon. A horizontal rock has no dip. The difference between the plane of a stratum and the horizontal line is called the amount of dip.

Q. What is meant by strike?

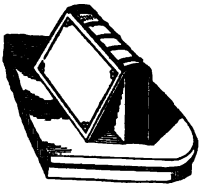
A. The strike is the direction in which the edge of a stratum appears at the surface. The strike is always at

right angles with the dip. If the dip be east and west the strike will be north and south.

Q. Can you give a familiar illustration?

A. A row of houses will aptly illustrate both the strike and dip. The ridge of the roof will represent the strike of the rock, the sloping sides the dip. A very ready illustration can also be found by placing a book on a table with the leaves downward (fig. 5). The back of the book *a a* will represent the strike, while the cover may be raised or lowered to illustrate various amounts of dip.

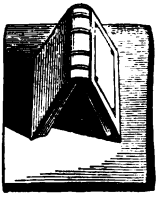
Fig. 5.



Q. What is the anticlinal line?

A. The anticlinal line, or axis, is the elevated portion of the rock from which the strata dip in opposite directions; and may be figured by a book (fig. 6), with the back up and both covers extended.

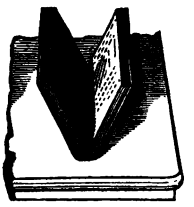
Fig. 6.



Q. What is the synclinal line or axis?

A. The synclinal line is just the reverse of the anticlinal, being the line running along the lowest part of a curve, towards which the strata descend on both sides. It may be represented by putting the back of the book on the table (fig. 7), and opening the covers outward.

Fig. 7.



Q. What is a qua-quâ-versal dip?

A. When the strata dip in every direction from a given point, it is termed a qua-quâ-versal dip. This is owing

to their having been forced up into a dome-like mass, the top of which being worn off, leaves the strata in the form of circles round a central point.

Q. Do strata always conform in position to each other?

A. By no means. The earth has been subjected to so many changes; violent upheavals and dislocations in some places; in others, gradual settlings of the dry portions beneath the sea, or elevations of the ocean bed above the surface; that only those strata deposited in the periods of time, between such changes, could correspond in position to each other.

Q. What are such strata called?

Fig. 8.

A. They are called conformable. When such strata have been disturbed, from their original horizontal position, and after being raised to a greater or less angle with the horizon, another series of strata is deposited horizontally over them, the new strata, though conformable with themselves, are unconformable to the lower beds (fig. 8). The layers *a* are unconformable to the layers *b*.

Q. Are the different layers of a rock of the same thickness throughout their whole extent?

Fig. 9.

A. No; they are sometimes quite wedge shaped (fig. 9), either because they were deposited by a stream of water or because a portion of the stratum was worn away before the overlying one was formed.

Q. What is the usual thickness of strata?

A. They vary from several feet to a thickness not exceeding that of coarse paper. A very thin stratum is generally called a seam; though this term is sometimes intended to specify a thin layer of a different kind of rock from the strata above and below, as, a seam of coal, a seam of limestone, &c.

Q. What is meant by the lamination of a rock?

A. The laminæ (scales or plates) of a stratum may be described as bearing the same relation to it, that the stratum itself does to the series of strata to which it belongs.

Q. What has caused these laminæ?

A. Lamination is undoubtedly caused by the manner in which particles, settling in water, have been deposited, certain portions partially hardening before fresh particles settled over them. The settling of particles in still water, on a level surface, produces smooth, horizontal laminæ, like the folds of a quire of paper; on a steep shore, oblique laminæ; on a surface acted upon by waves, undulating laminæ. Frequently after deposition the beds have been subjected to lateral pressure (fig. 4), and the laminæ much contorted (fig. 10). Chemical attraction of the molecules (minute particles) will also change the relation of the parts after deposition.

Fig. 10.

Q. What is meant by joints?

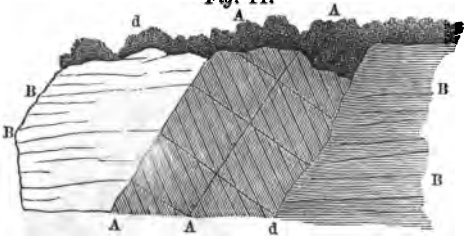
A. All the rocks, unstratified as well as stratified, are crossed by regular fissures of various sizes called joints. The most regular and extensive of these fissures are called master-joints.

Q. What is meant by cleavage?

A. Some rocks are susceptible of indefinite subdivision—into parallel planes, or sheets, which is called cleavage; this has no connection either with the joints, the lamination, or the stratification. Slate rocks present a fine illustration both of joints and cleavage.

Q. Is there no danger of confounding joints and cleavage?

Fig. 11.



A. They are easily distinguished by the fact that the portion of rock between two joints has no tendency to split in the same way, whereas it is easily separated to almost any degree of minuteness in the direction of the cleavage planes. The joints also do not, as a general thing, pervade the whole mass of the rock, while the cleavage is one of its characteristics (fig. 11). The planes of stratification, in the illustration, are marked by the figures B B, B B; the joints by A A, A A; and the cleavage by d d.

Q. What is meant by outcrop?

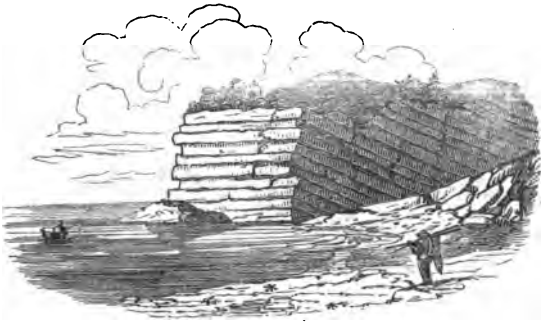
A. Where the strata come to the surface it is called by miners their outcrop or basseting.

Q. What is an escarpment?

A. The abrupt termination of strata in a headland

forming a steep cliff, is called an escarpment. Such a termination of strata often misleads the hasty observer as to the true dip. The appearance of the layers in horizontal lines in the cliff may by him be taken for the dip, while it is really the strike, and the amount of dip as seen from the side of the cliff is in fact considerable (fig. 12).

Fig. 12.

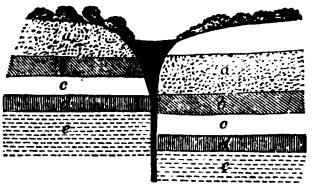


Apparent horizontality of inclined strata.

Q. What is meant by a fault?

A. The terms fault, trouble, slip, and shift, are all used by miners and geologists to express the break in the continuous line of strata, by the upheaval of one portion or the subsidence of another: as shown by fig. 13.

Fig. 13.

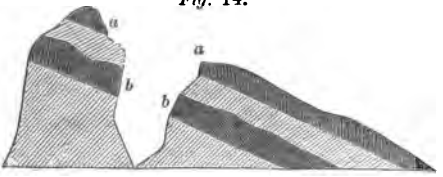


Q. What is an outlier?

A. When an isolated mass of rock is found to correspond in mineral character and fossils with a larger mass

in the neighborhood, it is said to be an outlier of the larger mass. The intervening portion having probably been washed away by currents of water (fig. 14).

Fig. 14.



Q. What is a formation?

A. The rocks deposited during any one of the geologic periods, though differing in many respects, yet having some leading features in common, constitute a formation; as the coal formation, the cretaceous formation, &c.

Q. What are veins and dikes?

A. Veins are masses of igneous rock thrown up from below, which gradually grow smaller, and at length disappear (fig. 15); or which on reaching an opening over-

Fig. 15.

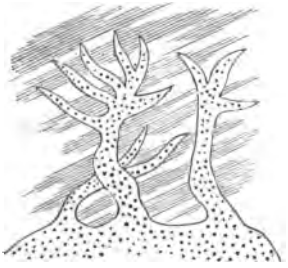
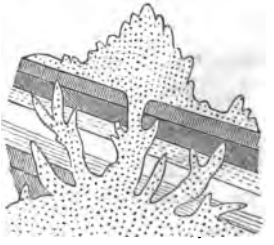


Fig. 16.



flow and form a bed (fig. 16). Dikes are large veins of Trap rock, Porphyry, or Lava. Veins are generally very crooked and irregular. Dikes are ordinarily straight.

CHAPTER IV.

CLASSIFYING ROCKS.

Q. What is the principal object in classifying rocks?

A. To obtain some idea of their age, which is determined by the position of the strata, by the fossils they contain, and by their mineral qualities.

Q. What is the most generally received classification?

A. One which divides all the stratified rocks into five classes, called Primary, Transition or Palæozoic, Secondary, Tertiary, and Quaternary. (See note *c*.)

Q. Describe the Primary.

A. These strata, resting upon the Igneous, or unstratified rocks, are of a dense crystalline structure, and contain no fossils. This class includes the metamorphic rocks.

Q. Describe the second class.

A. The Transition or Palæozoic (ancient life) formation is marked by the fossils of the earliest plants and animals. This class contains the great coal measures.

Q. Describe the third class.

A. The Secondary rocks, which form the third class in this system, begin with the New Red Sandstone above the Permian, and extend to the top of the Chalk. Some geologists prefer giving the name Secondary to all the rocks that occur between the Primary and Tertiary.

Q. Describe the fourth class.

A. The rocks belonging to the fourth, or Tertiary class,

are generally looser and more level than those of the first three. They are the first that contain any fossils that can be considered identical with living species.

Q. Describe the fifth class.

A. The fifth class is called Quaternary, and contains the surface earth, sand, gravel, clay, &c., along with the deposits of peat, marl, bog ores, and crumbled rock.

Q. Describe the unstratified rocks called Granite, which lie below the five classes.

A. They do not admit of a regular classification of succession, but may be arranged in groups according to their mineralogical characters.

Q. Name these groups.

A. First, the Granite Group, comprising Granite, Syenite, Serpentine, and Porphyry, of dense crystalline structure. Second, the Trap group—containing Basalt, Greenstone, Trachyte, and Amygdaloid, of less crystalline structure than the first. Third, the Volcanic Group, less crystalline than either.

Q. The classes of stratified rocks contain many groups: name those of the lowest.

A. The lowest class of rocks is called Primary, and rests directly on the Granite, into which the Gneiss insensibly slides; it contains Gneiss, Mica Slate, and Clay Slate.

Q. What are the names of the groups in the Transition or Palæozoic class?

A. Cambrian, Silurian, Old Red Sandstone or Devonian, Carboniferous, and Permian systems.

Q. What are the groups of the third or Secondary class?

A. They are called Trias, Lias, Oolite, Wealden, and Chalk or Cretaceous systems.

Q. What are the groups of the fourth or Tertiary class called?

A. Eocene, Meiocene, Pleiocene, and Pleistocene.

Q. What are the groups of the Quaternary or fifth class?

A. Diluvium and Alluvium.

Q. What are the tests made use of to ascertain the relative ages of strata?

A. Superposition, mineral character, and the animal and vegetable remains they contain.

Q. Which of these three modes is most to be relied upon?

A. Though the mineral qualities of a mass, and its order of succession, are of great importance, yet the organic remains it may contain afford the most decisive proof as to the period when it was deposited.

CHAPTER V.

FOSSILS.

Q. What is the name of that branch of geology which treats of the animal and vegetable remains found in rocks?

A. Palæontology.

Q. What is a fossil?

A. Any organic body, whether vegetable or animal, or the traces of any such body, or any substance produced by such a body (as a coprolite or a coin), buried by natural causes in the earth, is called a fossil.

Q. Do fossils differ in their state of preservation?

A. Very greatly. Some extinct animals have been

found entire, with their flesh, skin, and hair in perfect preservation; in other fossils no part of the animal has been preserved; but the space it occupied has been filled with mineral matter, forming a cast of the original.

Q. Do petrified bodies ever exhibit the organic structure as well as the external form?

A. They do to an extraordinary degree, exhibiting, in some instances, all the minute fibres and vessels in their proper places.

Q. What is meant by organs and organic structure?

A. As applied to animals and vegetables the term organs means those parts which are intended to accomplish any certain purpose, as the ears are the organs of hearing; the muscles are the organs of motion; the sap vessels are the organs of circulation. By organic structure is meant any body possessed of organs, or dependent upon organs for its growth.

Q. Under what forms do petrifactions occur?

A. Carbonate of Lime, the Oxyde, Carbonate, and Sulphate of Lead, and Silica.

Q. Do the relics of animals and vegetables occur in all the stratified rocks?

A. Yes; but in much greater numbers and better state of preservation in some than in others.

Q. What has been the medium through which fossils have been deposited?

A. Most generally by the ocean, these are termed marine; some in brackish water, they are called estuary deposits. The Tertiary series first show deposits of fresh-water shells and animals: these are denominated fluviatile, when deposited by rivers; lacustrine, when by lakes The number of water plants and animals far exceeds that of the land.

Q. What is Cuvier's classification of the animal kingdom?

A. He divides it into four great parts: the Radiated, Molluscan, Articulated, and Vertebrated.

Q. Why is the Radiated division so called?

A. Because their organs of sense or motion are arranged circularly, in radii from the centre. They have no nervous system, or have one very indistinctly marked. This division embraces three classes: first and highest in order Echinoder'mata (hedge-hog skinned), embracing Sea-Urchins, &c. Second, Acale'phæ (nettle-like), jelly fishes, Portuguese Man-of-war, &c. Third, Po'lypi (many footed), Polyps, Sponges, &c.

Q. Describe the Molluscan division.

A. This division receives its name from the Latin word mollis, soft; their nervous system is dispersed in irregular masses, their muscles attached to their skin, and most of them are covered with a shell. This division also embraces three classes.

Q. Describe them.

A. First, those whose tentacles (arms) are arranged about their mouth, as in the cuttle-fish; this class is called Ce'phalopo'da (head and foot together). The second class is called Ga'steropo'da (stomach and foot united); these move on a flat disk or foot, as snails, &c. The third class have no distinct heads, and are enclosed in bivalve shells, as the oyster and clam; they are called Ace'phala (without a head). The Cephalopoda abound in the older strata, the other two in the more recent rocks.

Q. From what does the Articulated division receive its name?

A. From Latin and Greek words which signify a limb

and jointed, because their bodies are covered by a series of movable rings, which constitute an articulated case.

Q. Describe this division.

A. The nervous system is arranged in two parallel cords, which at intervals swell into knots or ganglions: each one of the joints or rings, which compose their bodies, is furnished with ganglions. This division contains four classes.

Q. Name them.

A. First, Annel'idans or worms, including leeches; second, Crusta'ceans, like the crab and trilobite; third, Arach'nidans, resembling spiders; fourth, insects. Insects are the most numerous class of animals, but the most perishable, and few relics of them are found in the rocks. The oldest that have been found are in the coal.

Q. Describe the Vertebrate division.

A. This division receives its name from the vertebræ, or joints of the backbone; it comprehends all animals that have an internal skeleton. This skeleton, which protects the brain and spinal cord by its skull and vertebræ, is divided into two cavities, the one for the nervous centre, the other to protect the organs that produce digestion, breathing, and the circulation of the blood. It embraces four classes.

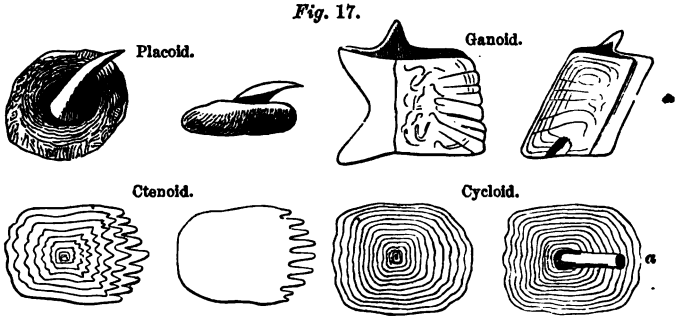
Q. Describe them.

A. First, Mammalia, animals that suckle their young; second, birds; third, reptiles, including lizards, snakes, turtles, and frogs; fourth, fishes. The oldest remains of fishes that have as yet been found occur in an upper bed of the Silurian system, immediately below the Old Red Sandstone, where also appear for the first time some remains of a terrestrial vegetation.

Q. How does Agassiz distinguish the fishes?

A. According to their coverings into four orders (fig. 17). First, Ganoids (from Greek *ganos*, splendor), with

Fig. 17.



Characteristic scales of the four orders of Fishes.—AGASSIZ.

enamelled scales, like the Gar-pike; second, Placoids (from Greek *plax*, a broad plate), with skins like shagreen, as the Shark and Skate; third, Ctenoids (from Greek *ktenos*, a comb), whose scales are cut at the edges like the teeth of a comb, of which the Perch is an example; fourth, Cycloids (from Greek *kuklos*, a circle), fishes whose scales have a smooth unbroken margin, as the Salmon.

CHAPTER VI.

REPTILES.

Q. When do reptiles first appear?

A. The first indications of reptiles occur at the close of the Old Red Sandstone, just as the first evidence of fishes is given at the close of the Silurian system.

Q. When do birds make their appearance?

A. The first signs of birds occur in their tracks imprinted on New Red Sandstone in Connecticut. About these impressions, however, much doubt exists. It is by some considered that the rock does not belong to the Trias, but to the higher Liassic formation; and as no bones of birds have been found below the Chalk it is contended that these tracks may have been made by some reptile of intermediate form not yet discovered.

Q. When do Mammals first appear?

A. The first remains of Mammaliferous animals that have been found occur in the Stonisfield-slate, a deposit which lies above the Inferior Oolite.

Q. Did the various creations reach their full development soon after their introduction?

A. Not until several formations after their first appearance did any of the divisions of the animal kingdom reach their greatest development.

Q. Agassiz distinguishes four ages of nature corresponding to geological formations. What is the first called?

A. The Palæ'ozoic (ancient life) age, embracing the Silurian and Old Red Sandstone formations; during this epoch no air-breathing animals existed. Zoophytes, Shell-fish, and Trilobites filled the seas. This is called the Reign of Fishes, though the vertebrate fish was only represented by two orders, has not been found below the Upper Silurian beds, and did not become abundant before the Devonian period.

Q. What is the name of the second age?

A. It is called the Reign of Reptiles, and embraces the Carboniferous, Permian, Triassic, Liassic, Oolitic, Wealden, and Cretaceous formations. Insects, reptiles, birds, and mammals appear in this age.

Q. What is the third age?

A. The Tertiary age, which is called the Reign of Mammals, embraces the Tertiary formations; Aquatic animals ceased to preponderate, immense terrestrial animals appeared in great numbers, and the resemblance to modern organisms steadily increased.

Q. What is the fourth age?

A. The fourth, or Modern Age, is called the Reign of Man; it comprises all the deposits since the Tertiary, and is characterized by the introduction of the higher forms of animals, with man at their head.

CHAPTER VII.

UNSTRATIFIED ROCKS.

Q. Describe the granite group of unstratified rocks.

A. Granite rocks are highly crystalline, have no stratification, and form the basis on which all the systems of strata repose.

Q. Do they always occupy the lowest place?

A. No; they form the summits of all the high mountains on the globe, and are also brought to the surface in the form of veins and dikes, being uplifted or injected by volcanic action.

Q. Of what is Granite composed?

A. Granite is composed of Quartz, Feldspar, and Mica. Metalliferous veins are most numerous in the Primary and Transition or Palæozoic classes. They are rarely worth working above the coal.

Q. Describe the Trap group of unstratified rocks.

A. Trap differs from Granite in containing less Silica, more Magnesia, Lime, Alumina, and Oxyde of Iron. It appears to have been thrown up in the form of lava, and occurs in dikes, dome-shaped masses, and in regular columns.

Q. What are the varieties of Trap rocks?

A. Greenstone, Basalt, Trachyte, and Serpentine. Trap rock, having almond-shaped cavities, caused by the escape of gases, and, subsequently, filled by the infiltration of other minerals, is called Amygdaloid; and a soft variety, resembling indurated clay, is called Wacke or Toadstone.

Q. Where Trap rocks have been intruded into strata, have they produced any effect on the adjacent rocks?

A. Their intense heat has in many instances entirely changed them. A Trap dike in Anglesea, passing through shale, turned it into Jasper, for the distance of thirty-five feet. In the north of Ireland Chalk has been changed, by the same cause, into Granular marble, and a coal bed reduced to cinders for nine feet on each side. In England the coal in the immediate vicinity was reduced to soot, and at a certain distance coked.

Q. Describe Basalt.

A. It is generally columnar, dividing great masses into regular prisms: the number of angles vary from three to twelve. The columns are divided into joints, sometimes fitted with concave and convex surfaces, like a ball and socket joint, sometimes merely lying flat on each other, but so nicely adjusted that a knife blade could not be introduced, either between the sides or joints of the columns, and yet each one can be lifted from its place.

Q. What is the cause of the columnar and globular form of volcanic rocks so conspicuous in Basalt?

A. It is ascertained by experiment that this form is the result of the crystalline arrangement of the particles, while cooling under great pressure.

Q. Describe the Volcanic group of unstratified rocks.

A. The term lava is applied to any rock that has flowed from a volcanic vent, but is generally confined to that thrown up by modern volcanoes. The ingredients of such lava are the same as those of the Trap rocks, but it is less compact and crystalline.

Q. Describe the different kinds of lava.

A. When melted lava cools rapidly it resembles smoky glass, and is called Obsidian, used by the ancient Mexicans for mirrors and knives—loose, slaggy matter thrown from volcanoes is called Scoria; when it is composed of feldspar it is porous and fibrous, and so light it will float on water; it is then called Pumice.

Q. What are Peperino and Pozzuolana?

A. Small particles of lava, with the light cinders and ashes thrown from volcanic vents, are called volcanic ashes; when cemented together they constitute Peperino and Pozzuolana.

Q. Describe the Primary stratified rocks.

A. According to the views now generally received, these were originally deposited as sediments by water, and afterwards altered by subterranean heat. They are composed of the same minerals as the granite rocks upon which they lie, and by the abrasion of which they were produced.

Q. What does Hutton say of the Granite group?

A. He considers the granite group to have been origi-

nally the same as the Primary, but from the intense heat and pressure to which it was subjected, to have crystallized without any evidence of stratification.

CHAPTER VIII.

PRIMARY ROCKS.

Q. Are the Primary rocks very thick?

A. Their thickness is variable, and the average is unascertained, but known in some places to be several miles.

Q. Are any fossils found in the Primary rocks?

A. None have been discovered. Either vegetables and animals did not live in the time when these rocks were deposited, or their remains were destroyed by the heat to which they were subjected.

Q. Is the order of succession, in the Primary class, invariable?

A. Not invariable, though Gneiss usually lies upon the Granite, and Mica Slate succeeds it.

Q. Are not the Primary rocks also called Metamorphic?

A. They are, on account of the change produced in them by heat, from their original sedimentary to their present crystalline character.

Q. Are they not also called Hypogene?

A. That name has been proposed by Lyell as indicating their position and character; the meaning of the word being "nether formed," or formed below the surface.

Q. Describe the class.

A. Serpentine belongs to this class as well as to the unstratified, already described. Primary Limestone, Quartz rock, and a great variety of slates, deriving their names from the minerals which preponderate in them, are found in this class.

Q. Are veins and dikes found in the Primary rocks?

A. The Primary strata are intersected by numerous veins and dikes of the igneous rocks, granite, porphyry, and greenstone. Metalliferous veins are numerous in this class of rocks, and in the Transition which succeeds it.

Q. Are there any Clay-slates in the Primary class?

A. Yes; Clay-slate, or Argillaceous schist, is common to the Metamorphic and Fossiliferous series.

CHAPTER IX.

PALÆOZOIC ROCKS.

Q. Describe the Transition or Palæozoic class.

A. Rocks of this class are of wide geographical diffusion; they are termed Palæozoic (ancient life), because they contain the most ancient fossils.

Q. Describe these fossils.

A. Representatives of all the classes of the animal kingdom are found in them. Of the Vertebrata fishes only have been discovered, the indications of reptiles in these rocks being as yet confined to their tracks in a few beds in the upper portion of the series.

Q. How are the Crustacea and Mollusca represented?

A. Trilobites (see fig. 20) are the principal representatives of the Crustacea; of the Mollusca the most numerous specimens in the Silurian rocks are the Ammonites and Nautili, belonging to the class Cephalopoda.

Q. What creatures represented the Radiate division?

A. Of the Radiata of the Palæozoic period, coral polyps are the most numerous; their fossils form a large portion of the limestone.

Q. Are plants at all conspicuous among the fossils of the Palæozoic or Transition strata?

A. When we ascend somewhat in the series, the plants form one of its most important features. The fossil plants of this period are of great variety, and amazing size.

Q. Describe the groups of the Palæozoic class, beginning with the lowest.

A. The Cambrian group lies at the bottom of this formation. It received its name from having been first investigated in Wales, anciently called Cambria. Some separate the lower portion into another group, which they term Cumbrian; and some geologists think the whole should be included in the Silurian group.

Q. What are the characteristics of the Cambrian group?

A. It is a marine formation, comprising vast beds of slate rocks, with dark-colored limestones and sandstones.

Q. How are these rocks divided?

A. They have been divided into the Snowdon rocks, Bala limestone, and Plynlimmon rocks.

Q. To what portion has the name Cumbrian been given?

A. To the fossiliferous slates of the Lake district in England.

Q. What is the estimated depth of the Cambrian and Cumbrian rocks?

A. They are estimated as being about 30,000 feet in thickness. They afford the first thinly-scattered evidences of life in a few fossils of the lowest orders, Polyps, Mollusks, and Algæ.

Fig. 18.

Oldhamia Antiqua.

Q. What is supposed to be the oldest organism known?

A. A Zoophyte, called Oldhamia Antiqua (fig. 18).

CHAPTER X.

SILURIAN SYSTEM.

Q. Describe the Silurian, which is next in order.

A. Sir R. Murchison investigated and classed these rocks, and gave them the name from the Silures, or Ancient Britons, who formerly inhabited that part of Britain where they are developed.

Q. What are the characteristics of this group?

A. The Silurian is a marine formation, and comprises limestones, sandstones, grits, flagstones, shales, and slates.

Q. How are the Silurian rocks divided?

A. They are divided into the Upper and Lower Silurian, which are again subdivided.

Q. Give these subdivisions.

A. The Lower Silurian contains the Llandeilo flag

formation, and the Caradoe sandstone. The Upper Silurian includes the Wenlock shale, Wenlock limestone, Aymestry limestone, and Upper Ludlow rocks.

Q. What is the estimated depth of the Silurian rocks?

A. About 7000 feet.

Q. Are all these divisions found in the rocks of this period in other parts of the world?

A. They are not, though a sufficient similarity is observed to make this classification the general standard.

Q. Where do these formations exhibit themselves?

A. They are to be found throughout the northern part of Europe, in Asia, Africa, and Australia, and are largely developed in North America. Specimens of them have been brought from the Arctic circle, and from Terra del Fuego.

Q. Will you mention in what part of North America they show themselves?

A. They cover a space of more than 10,000 square miles of the valley of the Ohio, and are extensively exhibited in Western and Central New York.

Q. Are the fossils of these early formations interesting?

A. Very much so, both on account of their being in all probability the beginning of animate creation on this world, and from their great dissimilarity to all modern organisms.

Q. In what order were the different divisions of the animal kingdom introduced in these rocks?

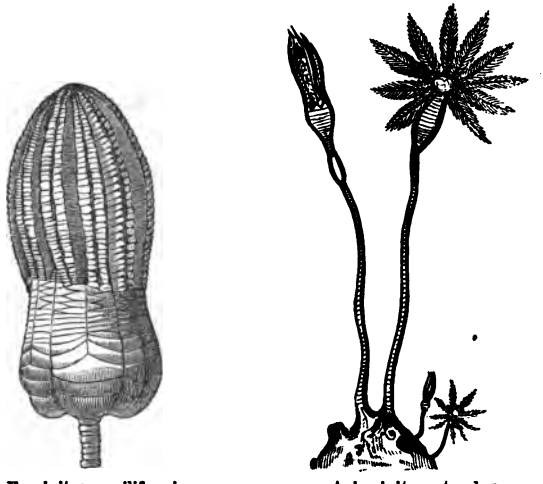
A. The fauna of the Cambrian group presents us with specimens of but two of the divisions of the animal kingdom, the Radiated and the Molluscan; the Lower Silurian adds the Articulated, and the Upper Silurian com-

pletes the list by giving us fishes, as the representatives of the Vertebrated.

Q. Describe the Silurian Radiata.

A. They are chiefly corals, that may have resembled the Sea-Anemone; Zoophytes, called, from their markings on the rocks, Graptolites, which perhaps were allied to the modern Sea-pens, which live in the muddy sediment of the ocean, and numerous Crinoids, or stone-lilies (fig. 19), a beautiful class of beings.

Fig. 19.



Encrinites moniliformis. Apiocrinites rotundus.

Q. What were the representatives of the Mollusca?

A. The most numerous representatives of this class belonged to its highest order, Cephalopoda. It is a strange thing, and worthy of remark, that the genus Terebratula, belonging to one of the lowest orders in the class, has some species in our modern oceans, while all the other genera are extinct.

Q. To what order does the Terebratula belong?

A. To the order Brachiopoda, a word which means the union of foot and arm.

Q. In what proportion of increase or decrease has this order been brought down to our times?

A. This order formed about one-fourth of the Mollusks of the earlier periods, and dwindled through the succeeding formations, till in the Tertiary seas it formed not more than one per cent. of the whole. From their ancient lineage the Terebratulæ have been called the Fossil Aristocracy.

Q. Are there any evidences of volcanic convulsions during the Cambrian and Silurian periods?

A. Yes, during this period Granite and other Igneous rocks were forced through the strata, changing their direction, in some instances rendering them nearly vertical.

Q. Do any existing mountains owe their elevation to these disturbances?

A. Many of the mountains of England, France, and Germany were uplifted at this time.

CHAPTER XI.

DEVONIAN SYSTEM.

Q. Describe the formation that lies above the Silurian.

A. The Old Red Sandstone, or Devonian group, lies between the Silurian and the Carboniferous systems, and like

those below, it is a marine formation. It is chiefly remarkable for its fishes.

Q. To what does it owe its names?

A. The name Devonian comes from its being well developed in the county of Devon, in England. The name Old Red Sandstone is from the dull, red color which pervades its marls and sandstones, owing to the presence of peroxyde of iron. It is called the Old Red to distinguish it from the New Red Sandstone, a deposit occurring much higher up in the series.

Q. How are the Devonian rocks divided?

A. Into three parts: first, Tilestone; second, Cornstone and Marl; third, Quartzose Conglomerate and Sandstone.

Q. Where has this system been investigated?

A. It has been carefully examined in Great Britain, Germany, Russia, and North America, and is known to exist in South America and Australia.

Q. Has not this system afforded an interesting proof of the value of fossils, as tests of the identity of formations?

A. It has done so. For a long time doubts existed as to whether the Sandstones of Devon and Hereford were of the same formation; these doubts were owing to the fact that the strata of Devon contained shells which were absent in those of Hereford, while the Herefordshire rocks contained fishes not found in those of Devonshire. Sir R. Murchison, when he visited Russia in 1840, discovered there beds of the Old Red Sandstone, containing the shells of Devonshire and the fishes of Herefordshire intermixed.

Q. What is the thickness of this system?

A. In England and Scotland it is 10,000 feet, but it is

much greater in some parts of the world. At the falls of the Ohio there is a beautiful exhibition of these rocks, abounding in well-preserved corals.

Q. What is the character of the organic remains of the Devonian rocks?

A. The organic remains of the Devonian system greatly resemble those of the Silurian, though an advance is marked by the great number of fishes, which were but sparingly introduced in the preceding period.

Q. Did the ancient fishes resemble the modern ones?

A. No; they were as peculiar and dissimilar from modern fishes as the other specimens of the animate creation from any creature now living.

Q. To what orders did the early fishes belong?

A. Entirely to the Ganoid and Placoid orders.

Q. Were both these orders introduced at the same time?

A. No; the fishes first introduced in the Upper Silurian beds were all Placoids; with the Old Red Sandstone the Ganoids were introduced, and in an abundance truly amazing; the seas swarmed with these two orders for untold ages, and through all the varied formations between the Silurian and the Chalk no specimen has been found of any other.

Q. When were the other two orders introduced?

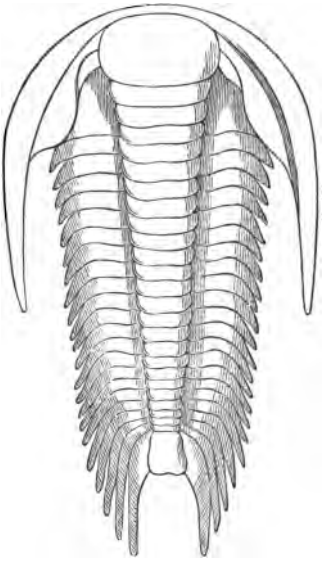
A. In the Cretaceous age the Ctenoid and Cycloid orders made their appearance, and the two which held sway so long are now only to be found in a few rarely-seen species.

Q. Why are some of the Ganoids called Sauroid fishes?

A. Reptiles are called Sauria, from the Greek, sauros, a lizard; and some of the Ganoid fishes in their heavy

armor, their teeth, and other peculiarities, so much approximate to reptiles they have been called Sauroid.

Fig. 20.

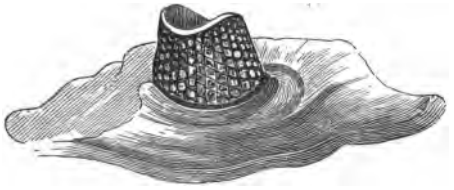


Trilobite.

Q. Did any conspicuous animal cease to exist in this age?

A. The Trilobite (from Latin, *tres*, three, and *lobus*, lobe), (fig. 20), with its beautifully-jointed armor, and its curious compound eye (fig. 21), which had filled the Silurian seas to such an extent that whole rocks are formed almost entirely of their remains, gradually faded away during the Devonian period, and after the Mountain Limestone, which succeeded it, was deposited, this strange creature existed in the world but as a fossil.

Fig. 21.



The compound Eye of a Trilobite.

Q. What were the plants of the Devonian system?

A. The plants of the Devonian group were mostly marine, and of a low order.

Q. Were they numerous?

A. Very much so, as, notwithstanding their fragile nature, enough of them have remained to give a fissle character to many of the slate beds, from the layers of Carbonated sea-weed.

Q. Was there any dry land in that age?

A. Some dry land must have existed, as in one of the lowest beds a small Lycopodite, a plant that somewhat resembles our club moss, has been found, with minute ferns and plants resembling the Calamites.

Q. Is there any advance in the vegetation as we ascend in the series of beds?

A. In the higher strata larger ferns and some specimens of true wood have been discovered.

Q. Is there any other evidence of dry land?

A. In addition to the terrestrial vegetation, we have the fact that several spots exist of Silurian and Devonian formations, with the succeeding systems abutting upon them. Proving the elevation of the first above the ocean before the last were deposited.

CHAPTER XII.

CARBONIFEROUS SYSTEM.

Q. Describe the Carboniferous system.

A. This system, so widely extended, and so essential to man's social prosperity, is composed of alternations of marine and fresh-water strata.

Q. What is the lower portion of this system?

A. A widely-extended series of fossiliferous limestones composes its lower portion; this limestone is rich in minerals, and is termed metalliferous.

Q. What minerals are found in it?

A. It is the great repository of Lead-ore; Iron is also abundant in it, and Manganese, Copper, Zinc, and Barytes are also found.

Q. Has the Carboniferous Limestone any other name?

A. It is also termed Mountain Limestone, and is remarkable for the size and beauty of its caves, which abound in Stalactites. Fluor-spar also occurs abundantly in veins, and is worked up into fancy articles of great beauty.

Q. Of what is the remainder of the system composed?

A. Of sandstones and dark bituminous shales, containing beds of coal. These vary so much in different localities it is difficult to form a classification that can be held as a standard; perhaps the one that arranges them in three divisions is the best.

Q. What are these divisions?

A. First, the Mountain Limestone, which comprises varieties of black, bluish, and mottled limestones, abounding with marine fossils, and passing into flagstone.

Q. Of what is the second division composed?

A. The second or middle division contains coarse, quartzose sandstone, passing into millstone grit and strata of shale; sandstone and grit, with layers of cornstone.

Q. What is the third or upper division?

A. The upper division is the all-important Coal formation, which contains some limestone, with both fresh-water and marine shells; then sandstone, shale, and coal alternating.

Q. Is not Iron sometimes found in the coal measures?

A. In some favored regions beds of clay and iron are mingled with the coal and limestone. The strata thus affording in themselves so many elements for manufacturing and commercial prosperity.

Q. Were there many shell-fish in the Carboniferous era?

A. The Trilobites disappeared with the Mountain Limestone, but the oceans abounded with a variety of shell-fish, and though there was less variety in the fresh water, the numbers were great.

Q. Were the Encrinites very numerous?

A. So much so that some varieties of the Flemish and Belgian marbles are composed almost entirely of their debris.

Q. Mention some of the other creatures that lived in that era.

A. Sauroid fishes of great size and strength were very numerous. Some insects, and reptiles allied to the Batrachian order, have also been found.

Q. What is the Batrachian order?

A. It is the lowest order among reptiles, to which frogs, salamanders, &c., belong.

Q. What are the characteristic fossils of this system?

A. The conspicuous feature of this period, which is so marked as to have conferred its name upon it, is its amazing flora, whose carbonized remains warm our houses, light our streets, drive our factories and steam vessels,

and in such various ways aid our rapidly-developing civilization.

Q. What is the character of the coal plants?

A. The flora of the coal measures is principally confined to the lower forms of plant life, yet the size which many of these reached redeems them from the insignificance of their living successors.

Q. Give some examples.

A. The club moss of our period expands in that warm and humid time into the giant Lepidodendron (scaly tree), (fig. 22), from fifty to seventy feet in height. The insig-

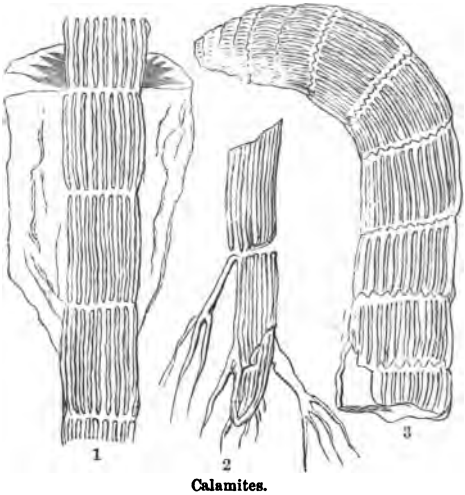
Fig. 22.

Branching Trunk of L. Sternbergii.

Branching Stem, with bark and leaves.

nificant Equisetum is the modern representative of the Ancient Calamite (reed) (fig. 23), which reached the height and size of an ordinary forest tree.

Fig. 23.



Calamites.

1. Calamite Radiatus (one-half natural size).
2. Stem with Roots (one-half natural size).
3. Calamite Approximatus (one-fifth natural size).

Q. Were the coal ferns equally gigantic?

A. The ferns varied in size from small ones that would suit our latitudes, to those of proportions that would even exceed the Tree Fern of Australia, that rivals the graceful Palm.

Q. Were the ferns numerous?

A. Astonishingly so, both as species and individuals.

Q. Did their numbers much exceed in relative proportion those of our time?

A. The flowering plants of Great Britain are estimated at 1400, her ferns at 41, being one to thirty-five. In her coal flora 300 species of plants have been discovered, 120 of which are ferns, making three-sevenths of the whole.

Q. How many plants have been discovered in the Carboniferous rocks?

A. As far as its flora has been investigated, it has yielded 500 plants, of which 250 are ferns.

Q. Were there any trees in that period?

A. Trees of the coniferous order, over a hundred feet in height, abounded in some places to such a degree that not even a small quantity of coal can be examined without finding their relics.

Q. Was the amount of the vegetation of the coal period as remarkable as its size?

A. The amount of vegetation necessary to form even the coal beds already discovered and worked, bewilders the imagination when we attempt to realize it.

Q. Has any estimate been attempted?

A. Some geologists have estimated that all the vegetation now in existence on the globe (and that of the tropics as much exceeds the vegetation of our latitudes as ours does that of Labrador), would not form a foot in depth of coal over the extent we know to be covered by coal beds.

Q. What does Elie de Beaumont say on this subject?

A. He says, that at the rate at which carbon is annually produced in our forests, not much more than six-tenths of an inch would be formed in a century.

Q. Can any estimate be formed of the relative bulk and weight of living wood and coal?

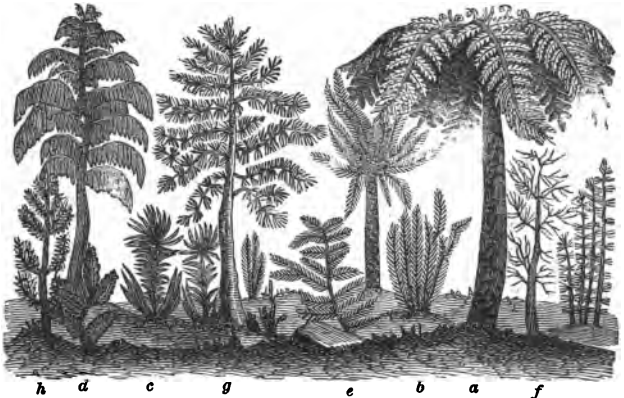
A. When the specific weight of wood and the amount of carbon it contains is estimated relatively to coal, we find the latter cannot be in bulk more than twenty-two hundredths at the greatest, down to seven hundredths,

according to the character of the plants of the original material.

Q. What was the general character of the coal plants?

A. Coal is in general formed of the lightest plants, Equisetacea (rush plants), ferns, &c. (fig. 24), and the lowest estimate given above probably exceeds the truth.

Fig. 24.



Vegetation of the Coal.

a Arborescent fern.
b Pecopteris.
c Asterophyllites.
d Neuropteris.
e Lepidodendron.
f Calamites.
g Araucaria.
h Casuerina.

Q. In what manner does coal present itself?

A. In the form of seams or beds, interstratified with sandstones and shales, the whole being arranged in the form of a basin.

Q. Are the seams numerous in any one place?

A. There are generally several together; one of the English coal fields has over a hundred layers.

Q. What is the usual thickness of the seams?

A. In thickness they vary as much as in numbers,

running from a fraction of an inch to 30 feet. One of the English coal fields has an aggregate thickness of 150 feet.

Q. Do the coal seams preserve much uniformity of thickness in themselves?

A. They do, even when they stretch over many miles. This is one of the arguments in favor of the plants having grown in the places where the coal is now found, instead of having been washed into heaps by currents and inundations, as some suppose.

Q. Describe one of the larger seams.

A. The Pittsburgh coal seam is ascertained to underlie an area of about 14,000 square miles, and has, throughout this vast extent, such identity of characteristics and subdivisions as proves wonderful uniformity in the circumstances under which its materials were brought together. It gradually diminishes in thickness towards the southwest, and is little more than three feet where it terminates.

Q. Where is the best and purest coal found?

A. Generally in the central layers.

Q. Are coal fields numerous on the globe?

A. Coal fields are constantly being discovered, as civilized man pushes his investigations, though many have doubtless been depressed since their deposition below our reach, and others elevated to an inaccessible height.

Q. Are we acquainted with any so elevated?

A. Those at Santa Fe de Bogota and at Huarochini, which are 8100 and 13,800 feet above the sea.

Q. What is supposed to have been the general aspect of the world during the Carboniferous era?

A. It probably presented a vast number of islands of

different sizes. This insular form of the land would be very favorable to vegetation.

Q. Are there any evidences of volcanic action in this epoch?

A. In some places the disturbance of the coal strata has been very great. It is less in this country than in Europe.

Q. What is the character of the rocks erupted into these strata?

A. The true granite eruptions appear to have ceased with the Devonian period; the Igneous rocks which invaded the Carboniferous strata are Trap and Metalliferous veins.

Q. Were any Mountain Chains thrown up?

A. Yes. To the mountains thrown up at this epoch the term Ballons, or rounded, ball-shaped mountains has been given.

Q. What is the depth of the Carboniferous system?

A. It varies greatly in different localities; in some, not exceeding 2000 feet, in others, reaching the thickness of 13,500 feet.

CHAPTER XIII.

PERMIAN SYSTEM.

Q. What system succeeds the Carboniferous?

A. The Permian system, so called from the district of Perm, in Russia, where it covers an extent of country between the Ural Mountains and the Volga, twice the size of France. It has a fauna peculiar to itself.

Does it occur anywhere else?

A. It is also seen in France and England, but is more fully developed in Germany, where it has been very carefully investigated.

Q. Does it make its appearance in America?

A. That is not yet ascertained, though some of its most remarkable fishes are found in some North American beds.

Q. This system marks the conclusion of the Palæozoic age; is there much change in its organisms?

A. The plants and fishes, though greatly resembling those of the Carboniferous period, are smaller and fewer; the principal change was in the indications of the coming reign, by the introduction of several varieties of reptiles.

Q. How may this system be divided?

A. It may be divided into two groups, the Lower New Red Sandstone and the Magnesian Limestone.

Q. Describe the Lower New Red Sandstone.

A. This series, which greatly resembles the coal measures it succeeds, is composed of a conglomerate, called Dolomitic Conglomerate, because it is formed of pebbles, cemented together by Magnesian Limestone, or Dolomite.

Q. Of what are these pebbles composed?

A. The pebbles are principally fragments of the underlying rocks. Marl beds, filled with remains of fishes to such a degree as to make them in some instances bituminous and fetid, are interspersed among these strata.

Q. Describe the Magnesian Limestone.

A. The Magnesian Limestone formation is interspersed with beds of Red Marl and Gypsum. In this stone the

Carbonates of Lime and Magnesia occur in nearly equal proportions. It is much valued for architectural purposes.

Q. In what manner is the impregnation of this rock with Magnesia, to such a degree, accounted for?

A. It is not easy to account for it; but some of the phenomena presented by it have given rise to the inference that the Magnesia was infused in the form of liquid, or vapor, after it was deposited.

Q. Does not this rock present some curious examples of spheroidal structure?

A. Yes; large masses exist, resembling piles of cannon balls. This form, it is believed, was assumed after its deposition.

Q. Is Oxyde of Iron present in this system?

A. It is highly charged with Oxyde of Iron, which may in some degree account for its poverty in fossils, all deposits in which this iron prevails being deficient in fossils.

Q. What is its depth?

A. It is estimated at about 1000 feet.

Q. Were any Mountain systems produced in this period?

A. Yes; those known to geologists as the systems of the North of England and of Hainault.

CHAPTER XIV.

SECONDARY PERIOD.

Q. We now enter on the Secondary period; give its general characteristics.

A. The rocks of this period are by no means so widely extended as the Palæozoic, some being entirely absent in extensive regions, and others developed in a comparatively limited locality. The period appears to have been marked by much disturbance of the earth's surface; upheavals in some places, and depressions in others.

Q. What is the name of the first, or lowest group, in the Secondary series?

A. The lowest group of the Secondary rocks is called, on the Continent, Trias, in England, Upper New Red Sandstone, Saliferous and Poikilitic.

Q. Why is it called on the Continent Trias?

A. Because there it is developed in three well-marked divisions.

Q. From what does it get its English names?

A. Upper New Red Sandstone comes from its position, its mineral ingredients, and color; Saliferous, from its beds of rock salt, and Poikilitic, from the variegated appearance of its conglomerates.

Q. Where does it develope itself?

A. It is very well developed in England and Europe, but is only exhibited partially elsewhere.

Q. How is it divided in England?

A. In England it has but two parts: First, the Lower

New Red Sandstone, containing sandstone and magnesian limestone; and, second, Sandstone and Quartzose Conglomerate, with the saliferous marls.

Q. What are the three German divisions?

A. First, Variegated Sandstone; second, Keuper and Muschelkalk; third, Variegated Marls.

Q. Does the Muschelkalk, which is absent in England, differ much from the upper and lower portions?

A. Yes, very much; it is a shelly limestone, rich in organic remains, in which the other portions are deficient.

Q. What is the depth of this system?

A. Its depth is estimated as being about 1200 feet.

Q. Did any change take place among the fishes of this period?

A. Until this period all the fishes had heterocercal tails, but during this epoch fishes with homocercal tails were introduced.

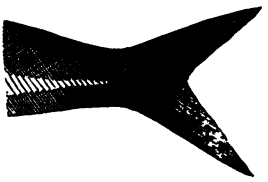
Fig. 25.

Heterocercal; Shark.

Q. Describe a heterocercal tail.

A. The spine was prolonged into the upper lobe of the tail (fig. 25), which was rendered longer than the other.

Fig. 26.



Homocercal; Herring.

Q. What is a homocercal tail?

A. In the homocercal tail the spine terminates at the root of the tail (fig. 26), and does not enter either lobe. This is the almost universal character of modern fishes.

Q. What was the character of the plants of this period?

A. In this epoch the immense ferns and Equisitacea appear to have gradually diminished, while the Conifers increased, and plants analogous to the Zamia and Cyclas took their place, destined to an immense development in the succeeding period.

Q. Were any reptiles introduced?

A. Several new reptiles made their appearance; they were all of the Marine, Saurian, and Lizard orders.

Q. In what is this system most valuable to man?

A. In its rich stores of salt, gypsum, and soda.

Q. Is salt peculiar to this system?

A. It is not, for it is found in the Devonian, and upward through the succeeding formations, to the Tertiary, yet it is eminently characteristic of the Trias in England.

Q. To what cause are these masses of rock-salt attributed?

A. Three theories have been advanced: First, that it is a deposit from the ocean; second, that it was caused by the subsidence of salt lakes; third, that it is of volcanic origin.

Q. Which appears the most tenable of these theories?

A. When we consider the vast amount of water that would be needed to form solid masses of salt several hundred feet in thickness, the first two theories seem untenable. The purity of the beds is another argument against their being sedimentary deposits; while the volcanic theory is strengthened by the fact that Chloride of Sodium (common salt) is frequently thrown up by volcanoes, and that brine springs rise from granite rocks.

Q. What system of mountains belongs to this period?

A. What is called the System of the Rhine.

CHAPTER XV.

LIASSIC SYSTEM.

Q. What is the name of the second group, as we ascend in the Secondary rocks?

A. The name of this group is Lias; this name is derived, it is supposed, from a provincial English word, which signifies layers.

Q. In what way is the term applicable to these rocks?

A. It seems intended to describe the riband-like appearance which this formation presents when a section is exposed.

Q. How is this striped appearance produced?

A. The alternation of layers of light brownish limestone with white and greenish marly sandstone, and dark argillaceous layers, give it, at a little distance, a riband-like appearance.

Q. Where does this system exhibit itself?

A. It is well developed in England, France, Switzerland, and Germany; is supposed to exist in Asia and South America, but to be absent in North America.

Q. What are the characteristics of this group?

A. It is a marine formation, and principally argillaceous, but having so much calcareous matter interspersed that the clay and marl beds are varied by bands of argillaceous limestone. There are also a few beds of sandstone, which, blending with the marl, produce layers of marly sandstone.

Q. Of what thickness is the Liassic formation?

A. It varies in thickness from 500 to 1000 feet.

Q. How is it divided?

A. Into four parts, of which the Upper Lias, which is very rich in fossils, and contains jet and bituminized wood, and the Lower Lias, which is an argillaceous limestone, occasionally changing into sandstone, and containing many fishes, keep their positions, but the intermediate divisions, the Lower Lias Shale and the Marl-stone, vary in different localities.

Q. Is this system rich in fossils?

A. Extremely so. It offers some of the strangest forms discovered by the geologist. The reptiles, whose reign we have now entered upon, taking possession of the fish form, present us with the gigantic Ichthyosaurus and Plesiosaurus.

Q. What is the meaning of the name Icthyosaurus?

A. It is from two Greek words, meaning fish and lizard, and signifies fish-lizard.

Q. Describe the Icthyosaurus.

A. They were of immense size, some being upwards of 30 feet in length; they had a wrinkled skin, like the whale, with great paddles to force them along; the general shape was that of a fish (fig. 27), with teeth like a crocodile; some individuals had a mouth with an open-

Fig. 27.

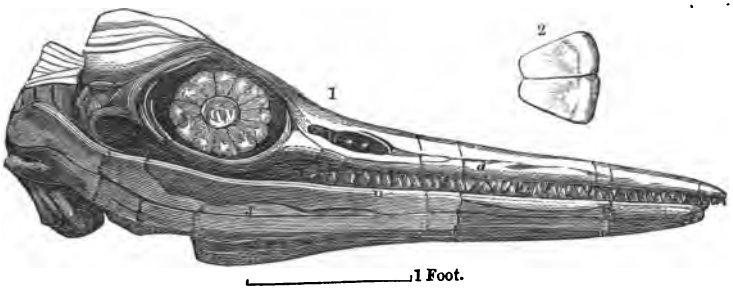
Restored figure of the Icthyosaurus.

ing of seven feet. The head was like a lizard's, the eye extraordinarily large, in some specimens having an orbit of eighteen inches diameter.

Q. Is there not something beside its great size that renders the eye of the Icthyosaurus interesting?

A. Yes; it had a peculiar arrangement of thin, bony plates on the outer coat of the eye, which enabled it to adapt the organ to great variations in light and distance (fig. 28); endowing it, in fact, with microscopic and telescopic properties.

Fig. 28.



1. Head of Icthyosaurus from Lias, Eng.
2. Two of the bony plates in the sclerotic coat of the eye.

Q. What is meaning of the name Plesiosaurus?

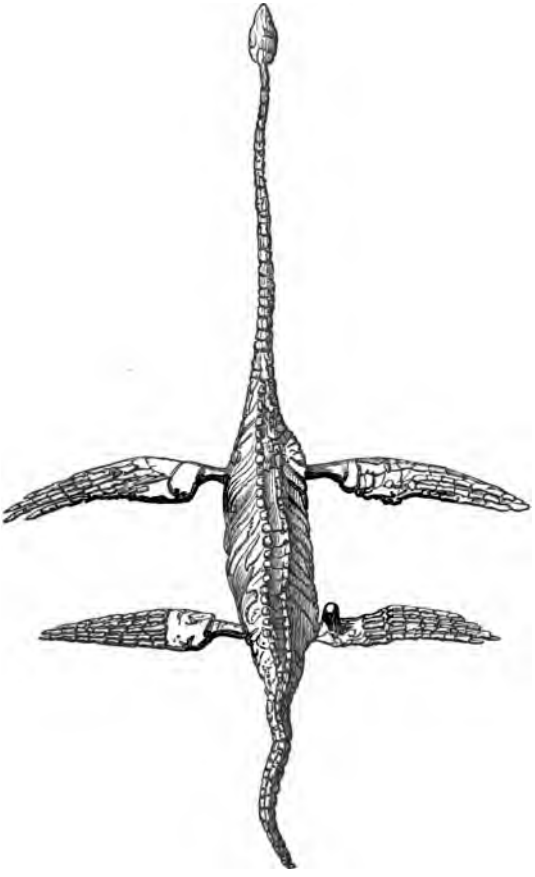
A. It means nearly a lizard. This creature seems to have been formed for life on the surface of the water, as the Icthyosaurus was for ranging the various depths of the ocean.

Q. Describe the Plesiosaurus.

A. Like the Icthyosaurus, it united the characteristics of several quadrupeds; it had the lizard-like head and the crocodilian teeth, but the neck was long and slender,

like the body of a serpent (fig. 29), and its trunk and tail had the proportions of an ordinary quadruped; the ribs were like the chameleon, and the paddles like the whale.

Fig. 29.



Plesiosaurus grandipinnis.

Q. Was not the Pterodactyle introduced in the Lias?

A. It was, and may be considered as being, on the whole, the most extraordinary creature yet disentombed from the rocks; not the largest, but the strangest.

Q. What is the meaning of the word?

A. It is derived from two Greek words, which signify wing and finger, because the radical finger was immensely elongated, and sustained a bat-like wing.

Q. Are there many varieties of the Pterodactyle?

A. As yet but one genus has been found, comprising seventeen species, one in the Lias, fifteen in the Oolite, and one in the Wealden.

Q. What was the size of the Pterodactyle?

A. The body of the animal was not large in propor-

Fig. 30.

Pterodactylus crassirostris; Goldfuss.

tion to its wings, which varied in the different species, from a sweep of only a few feet to 17 and 18, and one taken from the green-sand measures 27 feet.

Q. Describe the appearance of the Pterodactyle.

A. In the length of its neck and the form of its head, it resembled a bird (fig. 30), but the jaws and teeth were those of a reptile, while the back and tail were like a quadruped, its membraneous wings were supported by the elongation of the radical finger, but do not appear to have enveloped its feet to such a degree as to prevent walking.

Q. Between what creatures does this seem to be the connecting link?

A. The peculiarities of the bird, the bat, and the reptile are all represented by it, and to all three was it at first assigned by different naturalists. It could fly, walk, climb, and probably swim.

Q. What is supposed to have been its food?

A. Large quantities of insects have been found in their intestines, and as many fossil insects are found in the quarries from which the Pterodactyles have been extracted, it is probable that insects made a large portion of the food of the smaller species. The larger kinds possibly devoured the small marsupial mammalia that then existed, or darted upon fishes from the air, as many sea-birds do.

Q. Has food been found in the stomach or intestines of any other fossil creature?

A. Yes, in many. Fishes, &c., have been found in many Saurians, and vegetable matter in the stomachs of Pachyderms.

Q. Were birds introduced in this era?

A. Their skeletons do not occur before we reach the chalk, but their existence is marked by numerous foot-marks, of different sizes and forms, indicating different species, on some of the rocks of this period.

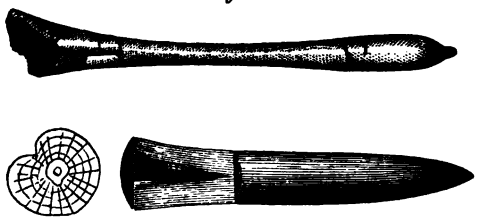
Q. Do the celebrated Connecticut impressions belong to this period?

A. The strata in which those impressions occur was for a long time held to belong to the Trias, but is now considered as a Liassic deposit. There is increasing doubt as to these impressions having been made by birds, the suggestion that they are the tracks of some unknown reptile which united the characteristics of the two orders, appears to gain ground.

Q. What were the corals of the Lias?

A. They were few and small, but the bed of its ocean was covered with the beautiful plant-like Crinoides. Many Belemnites (fig. 31), are found, and the graceful

Fig. 31.



Belem'nites Sulca'tus.

Ammonite abounded to such a degree in these successive formations that Miller designates the Reptilian Reign as emphatically "the period of the ammonite and belemnite."

Q. Were the Ammonites numerous in species as well as individuals?

A. Five hundred and fifty-two species have been recorded; two occur in the Upper Silurian, but the increase was small until the Lias, from the different beds of which in France D'Orbigny has taken 142 species, they abounded in the Oolitic and Chalk rocks, but are now extinct.

Fig. 32.

Q. Describe the Ammonite.

A. It is a spiral, chambered shell (fig. 32), curled on a plane; it may be compared to the architectural ornament termed a volute. It contains so many and such wondrous contrivances for the union of strength and lightness, that the architect may derive many hints from its examination. Its corrugated (fig. 33) shell shows forth the principle which modern science has prided itself on applying to the lifeboat.

Ammonites Varians; Chalk.

Fig. 33.

Ammonites Jason; Oxford clay.

Q. What evidence of dry land do these deposits afford?

A. The numbers of insects is conclusive proof that dry land must have abounded in the neighborhood of the oceans inhabited by these strange Saurians.

Q. What system of mountains is referred to this epoch?

A. The system of Thuringerwald.

CHAPTER XVI.

OOLITIC SYSTEM.

Q. Describe the Oolitic system, and give the reason for the name.

A. The Oolite, which is the middle group in the Secondary rocks, is so called from two Greek words, which signify egg and stone, on account of a granular variety of carbonate of lime, frequently called roe-stone or egg-bag.

Q. When these egg-like stones are broken what are they found to contain?

A. They are always found to contain some minute

substance, such as a fragment of coral, a shell, a grain of sand, &c., which forms a nucleus round which the lime has gathered.

Q. Are such beds frequently met with in this system?

A. They occur so frequently that they have given the name to the whole system, though a concretionary form is not strictly characteristic of it.

Q. Is not this system also called Jurassic?

A. It is from the Jura Mountains, the mass of which is formed by these rocks.

Q. In what other parts of the world is it met with?

A. It is developed in England, France, Germany, Poland, Russia, Portugal, and Spain. It occurs in India, but is very moderately developed in our country, where the transition from the Trias to the Chalk is generally abrupt.

Q. Describe the Oolite.

A. It is a marine formation, and consists of alternations of limestones and clays.

Q. How is it divided?

A. Into several groups, which are distinguishable from each other by the relative period of their deposition.

Q. What is the guide to ascertain these groups?

A. The fossils they contain form the surest guides, as each division has those characteristic of itself alone.

Q. Are the strata of the Oolite numerous?

A. So much so as to require a very cumbrous system of divisions for practical purposes.

Q. Is there no simpler system that may answer for present use?

A. Yes, one that would arrange the formations in three grand divisions, Lower, Middle, and Upper Oolite. These

three form hard calcareous beds, which in England and France make three successive ridges, while the strata of clays and shales are worn down to form the intervening valleys.

Q. Is the Oolite valuable in an economic point of view?

A. Very much so, as it abounds with limestones well suited to building purposes.

Q. Are there many fossils in the Oolite?

A. It is very rich in fossils of corals, shells, fishes, and reptiles. The first mammals are found in it, and a great variety of plants.

Q. Where are the corals found?

A. Principally in the Middle Oolite, where they occur in vast numbers, sometimes constituting the larger part of great masses of limestone.

Q. Were there many other shells?

A. Yes, Crinoids, Sea-urchins, and Mollusks are very abundant throughout this system.

Q. Is there in any of these Oolitic fossils a resemblance to living organisms?

A. The Crustacea of the Oolite greatly resembled those of our day.

Q. In what state of preservation are the insects?

A. Some are so beautifully preserved that the fine markings of their wings can be clearly traced.

Q. Are the fishes numerous?

A. They abound throughout the series, and the homocercal tail was nearly universal.

Q. What can you say of the Oolitic vegetation?

A. The plants of the Oolite were numerous and large, and as a consequence the coal beds are in some places

valuable, and are worked. In many places, however, though the genuine coal exists, the seams are not thick enough to repay the expense of mining.

Q. How are the reptiles of the Oolite?

A. The reptiles of this period are not as well preserved as those of the Lias; they retain the same saurian character.

Q. What is the most interesting palæontological feature of this system?

A. The discovery, in the Stonisfield slate, a deposit of the Lower Oolite, of the bones of two genera of small mammals. They both belong to the Marsupials, or pouched animals, one of the most imperfect orders, and which is represented now by the Kangaroo, and other Australian animals.

Q. What was the depth of the Oolite?

A. About 2000 feet.

Q. Are there any mountain systems belonging to this epoch?

A. That of Côte d'Or is referred to it.

CHAPTER XVII.

WEALDEN SYSTEM.

Q. What group succeeds the Oolite?

A. The Wealden, which takes its name from the part of England where it is most fully developed, a district in Kent, Surrey, and Sussex, which is called the Weald.

Q. What is the derivation and meaning of the word?

A. It is derived from Wald, or Wold, Saxon words, which signify a wood, or forest. Extensive forests formerly covered that district.

Q. What is the nature of the Wealden formation?

A. Up to this period, with some few exceptions, all the deposited strata give unmistakeable proofs of being marine; the Wealden clearly owes its origin to an immense fresh-water river or rivers.

Q. Has this deposit always been looked upon as a separate formation?

A. For a long time this deposit was included in the Cretaceous system, and some still place it there; others class it with the Oolite, but its characteristics are too marked to allow it to be merged in either.

Q. Is the Wealden visible on the continent?

A. The English layers dip under the sea, form the bed of the English Channel, and reappear on the other side; they are also seen in Germany.

Q. Have they not been met with in any other parts of the world?

A. As yet no other beds that could be classed with them have been discovered, but in all probability, as geologic research goes on, other fluviatile deposits of this period will be found.

Q. Of what is the Wealden composed?

A. Of layers of sandstones, limestones, conglomerate, and clays.

Q. What is its thickness?

A. It is estimated at 1000 feet.

Q. Are the fossils all of fresh-water origin?

A. They are principally fresh-water and terrestrial, although there are abundant evidences of successive de-

pressions and elevations by the interposition of several marine and brackish deposits.

Q. Is there much variety among the Wealden fossils?

A. The variety of species is by no means extraordinary, but the numbers of the individuals are almost unparalleled. Some of the strata are entirely composed of their cemented remains.

Q. Mention some of these stones.

A. The celebrated Purbeck quarries, near the Isle of Wight, are composed of layers of useful stone of a total thickness of 275 feet, belonging to the Wealden. These layers are principally composed of petrified Paludinæ, or river snails, and other small shells.

Q. What is the Sussex marble?

A. Of much the same composition as the Purbeck beds. It was much used by the Romans (fig. 34), and so much admired in the middle ages that hardly a handsome ecclesiastical edifice of that period exists in which the ornamental parts are not formed of it.

Fig. 34.

Sussex Marble, composed of Paludinæ.

Q. Are shells the only fossils found in those Wealden stones which are suitable for building purposes?

A. Shells, particularly those of the Paludinæ, Cyclas, and Unio, fresh-water genera, are the prevailing organisms, but there also occur bones of saurian and chelonian (tortoise) reptiles, with the remains of fishes and crustaceans.

Q. What is the character of the lowest bed of the Wealden?

A. This bed (fig. 35), which is a fresh-water bed, and rests directly on the Oolite, is a mass of bituminized earth. It is the famous "dirt-bed."

Fig. 35.

Section of the Isle of Portland, Dorset, Eng.

Q. What are its fossils?

A. It presents the fossilized trunks and roots of an old forest, which, after its Oolitic base had been elevated long enough to permit eighteen inches of soil to accumulate, and forest trees to reach maturity, was submerged so gently that the upright trunks and undisturbed roots were borne beneath the waters, to be surrounded by succeeding layers.

Q. Is this "dirt-bed" extensive?

A. It extends from the Isle of Portland, where first seen, to the coast of Dorsetshire, and to the opposite cliffs on the French coast. Traces of it have also been observed in Oxfordshire.

Q. Does this stratum preserve the horizontal position?

A. No; in some places, with its accompanying strata,

it has been elevated to an angle of 45 degrees, carrying its trees with it in their original relations.

Q. Are there other traces of vegetation in this formation beside the trees?

A. Yes; the same bed contains many remains of Cycadea (from Cycas, a little palm) (see fig. 36). From their rounded shape they are called birds' nests by the workmen.

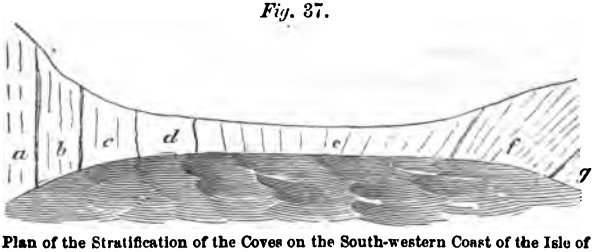
Fig. 36.

Mantellia nidiformis.

Q. Are the Wealden and chalk strata much displaced?

In some places they have been thrown up to a vertical position (fig. 37), affording a fine opportunity for observing the successive layers.

Fig. 37.



Plan of the Stratification of the Coves on the South-western Coast of the Isle of Purbeck. *a*, Chalk; *b*, Chalk-marl; *c*, Firestone; *d*, Gault; *e*, Wealden; *f*, Purbeck; *g*, Portland Oolite.

Q. Mention the fossils of the Wealden.

A. They consist of fresh-water shells, fishes, turtles, pterodactyles, colossal reptiles, birds, and terrestrial plants.

Q. What is the characteristic of the plants?

A. They are allied to those now indigenous to the torrid zone.

Q. What was the character of the turtles?

A. Of the three genera, one is marine, the other two fresh-water.

Q. What of the reptiles?

A. The Hylæosaurus, or Weald lizard, was an immense reptile, twenty feet in length. The great peculiarity of this Saurian was in a range of angular spinous bones, supposed to have been inserted over the spine, from the neck to the tail.

Q. Describe the Iguanodon.

A. This, the most gigantic of the reptiles, was an herbivorous creature, nearly thirty feet in length, and of elephantine proportions. One femur (thigh bone) has been discovered four feet in length.

Q. Has any coal been found in the Wealden?

A. In Germany, coal of considerable thickness has been found in this formation.

CHAPTER XVIII.

CRETACEOUS SYSTEM.

Q. What is the name of the last group of the Secondary rocks?

A. It is called the Cretaceous system, from Creta (chalk), which is its characteristic feature.

Q. Where does this system occur?

A. It is extensively developed in Britain, Europe,

India, North-eastern Africa, South America, and the United States.

Q. Does true white chalk occur in all these places?

A. The true white chalk is found in England, France, Denmark, Poland, Central Russia, and the Caucasus.

Q. Is there none in the United States?

A. In this country no true chalk has as yet been found, though the beds are highly calcareous (limy). In some instances they are chiefly arenaceous (sandy).

Q. How is this system divided?

A. It may be divided into four parts: First, Greensand; second, Chalk marl; third, Chalk without flints; fourth, Chalk with flints.

Q. What is the character of the formation?

A. It is entirely a marine deposit, and abounds with marine fossils.

Q. What are they?

A. Marine plants, corals, sponges, echinodermata, ammonites, belemnites, fishes, and reptiles.

Q. Are there no terrestrial relics?

A. There are occasional specimens of wood and land plants, that may have drifted into the sea.

Q. What has this system originally been?

A. In all probability the bed of an immense ocean, for a rival to which we must look to the oceans of the Southern Hemisphere, where the same operations are going on which the convulsions and upheavals subsequent to the Chalk period enable us to investigate in this system.

Q. Give some illustration of such formations now progressing.

A. Throughout the West India islands the formation of rocks resembling those of the chalk can be readily

traced; the waves dash on the shore minute fragments of shells and corals, and the wind bears this calcareous powder inland, where it becomes consolidated by the infiltration of water.

Q. Is such stone of a firm texture?

A. Perfectly so; the famous human skeleton of Gaudaloupe is embedded in a rock of this description.

Q. Is it probable such accumulations are going on in the bed of the ocean?

A. The fishes of those tropical seas are seen, as it were, browsing on the living coral polyps; after extracting the nutritious portions, the calcareous part is rejected, in a substance which resembles pure chalk, and is nearly clear carbonate of lime. This, added to the vast numbers of corals and shells, is doubtless forming masses, that will only differ from those of the chalk period, in the genera and species they contain.

Q. Describe the green-sand.

A. This, the lowest formation in the group, is in some places a silicious, and in others a marly sand. The green color is produced by Silicate of Iron. It is sometimes yellowish, or gray, from the Oxyde of Iron, and is intermixed with beds of dark blue clay, and clayey sand.

Q. What is chalk?

A. Chalk is an earthy form of Carbonate of Lime, sometimes sufficiently consolidated to be suitable for building purposes.

Q. What is the pure white chalk with which we are all familiar?

A. White chalk is nearly pure Carbonate of Lime, and is in general mainly composed of microscopic shells, and the fragments of larger ones.

Q. What was the opinion formerly of the origin of chalk, with the flint nodules which are scattered through it?

A. It was formerly supposed that chalk and flint were formed by the rushing of heated water, highly charged with lime and silica, into the colder waters of the ocean, where the calcareous and silicious substances were precipitated, and, uniting with each other by the laws of chemical affinity, produced chalk and flint.

Q. What has led to change in this view?

A. Observant men of science had, at different times, expressed doubts as to this origin. Linnæus, a century ago, declared his conviction that the calcareous strata were of animal origin, and microscopic investigations have since proved the correctness of his opinion, especially in regard to the chalk.

Q. Give an account of some of these discoveries.

A. Ehrenberg, who has devoted much time and skill to these observations, has made calculations which show that there are organized beings so minute that in a cubic inch of water a greater number could swim freely than there are human beings on the globe.

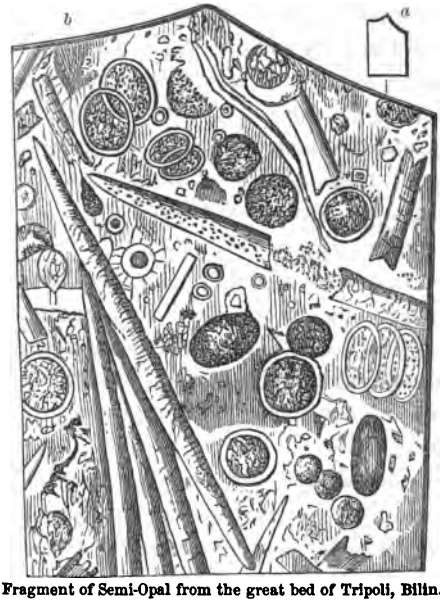
Q. Can such minute creatures leave any permanent relics?

A. Some of this minute class, which is termed Infusoria, have silicious shields, very beautifully marked and ornamented. Great numbers of these, in beautiful preservation, are found in opal, semi-opal (fig. 38), chalk, marl, flint, and marble. Microscopists have also shown that most of the Tertiary beds of Europe and America contain vast accumulations of these microscopic fossils.

Q. Are there any other minute organisms which are sufficiently numerous to affect the surface of the earth by their accumulations?

A. There are many. To mention one may suffice: the

Fig. 38.



Fragment of Semi-Opal from the great bed of Tripoli, Bilin.

a, Natural size.

b, The same magnified, showing circular articulations of a species of Gaillonella, and spiculæ of Spongilla.

Foraminifera, also microscopic creatures, of a gelatinous substance, which secrete a delicate calcareous chambered shell. Six thousand shells, of this genus, were collected from an ounce of sand from the shores of the Adriatic, and upwards of 3,000,000 are said to have been found by D'Orbigny, in the same quantity of sand from the Antilles.

Q. Do these creatures increase rapidly?

A. With such rapidity that it far more than compensates for their small size. The bones of Elephants, or

even the most numerous of the quadrupeds, form a hardly appreciable amount of the surface of the globe; but these creatures are now choking up the harbor of Wismar, in the Baltic, changing the bed of the Nile, in Nubia, and the Elbe, at Cuxhaven.

Q. Mention some of the rocks composed of these small beings.

A. Those masses called Tripoli, a substance used in polishing hard surfaces, are entirely composed of them. The town of Richmond, Va., stands over a stratum twenty-eight feet thick of fossil infusoria, principally composed of two genera. They enter largely into all the cretaceous and Tertiary beds, and are found in many limestone layers of great thickness, which extend for leagues.

Q. What inference may we fairly draw from these positive discoveries?

A. That farther research and more extended observation will prove that very large portions of all the sedimentary rocks owe their special characteristics to having passed through the great laboratory of animated existence. A view of creative action as overwhelming to the mind as the sublime revelations of the Telescope. (See note *d*.)

Q. In what way does the flint occur in the chalk?

A. Sometimes in flat masses, but most generally in nodules of various sizes, from less than an inch to several feet in circumference, and always separated from each other by a coating of chalk.

Q. Do these nodules ever present a nucleus round which they have been formed?

A. Yes, very generally. A sponge is a common thing whose form is frequently well preserved.

Q. To what are the nodules probably owing?

A. Probably to a concretionary tendency in the silica, similar to that so often seen in the clays. (Fig. 39.)

Fig. 39.

Septarium.

Q. What effect has it produced in the clays?

Fig. 40.

Septarium.

A. Various sized balls formed round a centre, and called septaria (septum, a division), because in drying they have generally cracked (fig. 40). They are so regular in form, that in England it is popularly thought they are artificial, and were used as money, and in this country they are attributed to the Indians.

Q. How are the planes of stratification in the chalk ascertained?

A. The deposits of flint nodules through the mass is the only mode of ascertaining them.

Q. Are the fossils of the chalk very numerous?

A. Very numerous, both as to varieties and individuals.

Q. Are they ever continued to the Tertiary system which succeeds the chalk?

A. In no instance is a species continued to the Tertiary; in many instances the genera themselves disappear; so marked is the separation between this last system of the Secondary rocks and the Epoch which succeeds it

Q. Are terrestrial Mammals found in the chalk?

A. As yet none have been discovered.

Q. Were reptiles still numerous?

A. Both aquatic and terrestrial reptiles were abundant, though but few new ones were added. Bones of different species of cetacea (whales) are found.

Q. What other fossils occur?

A. Fluviatile tortoises, fishes, and mollusks, and occasionally sharks, which are continued to the present time, though of a much smaller size.

Q. Describe the shells called Nummulites?

A. This shell belongs to the Foraminifera, which are generally microscopic creatures, but this, of which there are many species, sometimes reaches the diameter of an inch; it is a chambered shell, the animal, unlike the Nautilus, occupying all the chambers.

Q. What is the meaning of the name?

A. It means "stone money," from two Greek words having that signification; it is round and flat (fig. 41), and very much resembles a small coin.

Fig. 41.

Nummulite Limestone; Pyrenees.

a, External surface of Nummulites, of which longitudinal sections are seen in the Limestone.

b, Transverse section of same.

Q. Has this resemblance been popularly recognised?

A. It has. In Germany this fossil is called "The Peasant's Penny," "The Devil's Money," and in Egypt "Sphynx Money."

Q. Is it an abundant fossil?

A. Very abundant. In several of the formations forming layers of rock, called from it Nummulitic limestone, it underlies the greater part of Egypt, and was largely used in the construction of the Sphynx and the Pyramids. In Alabama there is a mountain range, composed entirely of one species of the Nummulite.

Q. What is the depth of the Cretaceous system?

A. From 1000 to 1500 feet.

Q. Are any Mountain systems to be dated from this epoch?

A. The system of Mont Viso.

CHAPTER XIX.

TERTIARY PERIOD.

Q. Describe the Tertiary period.

A. This epoch, which intervenes between the Secondary rocks and the Modern Age, is characterized by a great and increasing approximation in its flora and fauna to those of the present period.

Q. What is the character of its rocks?

A. From their position near the surface they have undergone much less pressure, and are looser in their texture than the lower deposits.

Q. Are the fossils of the Tertiary numerous?

A. They occur in vast numbers, and are in an admirable state of preservation, especially the shells.

Q. Were the oceans as extensive as those of former periods?

A. The seas were much less extensive, and as a consequence the Tertiary strata are not as widely spread as the preceding. They occur more in detached spots, though in some places vast tracts are covered by them.

Q. Where are they found?

A. They exist in all the present divisions of the globe; but are especially developed in Europe and South America.

Q. Are they found in North America?

A. Not so conspicuously. They make their appearance at Martha's Vineyard, continue down, and are largely spread over Virginia, North and South Carolina, and Alabama.

Q. What appears to have been the mode of their deposition?

A. They seem to have been deposited in depressions of the rocks, such as shallow lakes and bays.

Q. Are they marine or fresh-water deposits?

A. They exhibit frequent changes from fresh to salt water, and give many indications of volcanic action on a prodigious scale.

Q. Do they afford any evidences of change of climate?

A. Many circumstances would indicate that during this period a gradual chilling of the globe took place, until nearly our present form of climate was established.

Q. Are Mammalian remains found in these rocks?

A. This was the Reign of Mammals; very great num-

bers are found, and the reptiles gradually assumed the subordinate position they now occupy.

Q. What are the predominating rocks of the Tertiary?

A. Clays and sand predominate; the pressure they have been subjected to has not been sufficient to reduce them to shales and firm sandstones.

Q. What is the character of the Calcareous strata?

A. They are varied and marly, containing shells and rough masses of coral.

Q. Are the limestones of this group marine?

A. There are fresh-water beds of hard limestone, and marine limestone of a coarse, porous nature. There are also beds of Gypsum and Rock Salt, of Silica and Buhrstone.

Q. Is not this system widely different in character from those it rests upon?

A. It is so, but slides insensibly into the Modern, which succeeds it.

Q. How are these rocks classed?

A. At first they were classed according to the alternations of Marine and Fresh-water strata, but the great want of uniformity in the deposits in different places rendered this an unreliable test.

Q. What has been substituted for it?

A. Shells, the most numerous and most generally diffused of fossils, are now received as the basis of a classification, carefully made, and, as far as tested, quite satisfactory.

Q. What is the classification?

A. Three divisions have been adopted on this basis.

Q. Mention the first or oldest.

A. The first is called Eocene, from Greek words signifying dawn and recent. This includes the older Tertiary series, and signifies the dawn of the present period.

Q. What is the second division?

A. The second is called Meiocene, from words meaning less and recent, because, though containing more that resemble the present than the Eocene, yet the extinct species still predominate.

Q. What is the third called?

A. This is termed Pleiocene, from more and recent; signifying that in these beds the recent species preponderate.

Q. Is not the third division sometimes subdivided?

A. It is so, and is then called Pleiocene and Pleistocene, meaning respectively more and most recent.

Q. What proportion of recent shells is found in the Eocene?

A. The Eocene includes all the strata which have among their shells but three per cent. of existing species.

Q. What does the Meiocene contain?

A. The Meiocene contains eighteen per cent.

Q. What do the Pleiocene and Pleistocene contain?

A. The Pleiocene contains fifty per cent., and the Pleistocene ninety-five per cent.

Q. Is the Flora of the Tertiary made use of for classifying purposes?

A. The flora of the Tertiary has never been resorted to for this purpose, yet it possesses the same character of steady approximation to the Modern Age.

Q. What were the characteristics of the vegetation of this period?

A. The ferns and their allies sink to their present position, nor do the Conifers, which in the times of the

Oolite were so numerous, any longer predominate, but dicotyledonous trees and herbs, hitherto sparingly introduced, now became increasingly numerous.

Q. Were there any plants in the Eocene resembling ours?

A. In the Eocene woods, trees belonging to the same orders with the Oak, Beech, Hazel, Laurel, &c., were perhaps as frequently to be met with as in our own.

Q. Have any of these species been continued?

A. No species have been continued, yet the resemblance between them and the existing species is great.

Q. What do we find in the Pleistocene?

A. When we enter the Pleistocene we find many of our modern species; and though no living flora may be identical with any past one, as the late distinguished geologist Edward Forbes thought, there can be no doubt many of our trees are of great antiquity.

Q. What was the depth of the Tertiary system?

A. It is estimated at 2000 feet.

CHAPTER XX.

EOCENE.

Q. Describe the Eocene or older Tertiary beds?

A. These beds are very variable, consisting of sands, clays, gravel, marls, limestones, and gypsum.

Q. How does the Eocene exhibit itself in England?

A. The English Eocene is principally confined to three

distinct saucer-like basins, called respectively the London, Hampshire, and Isle of Wight basins.

Q. Have the layers been disturbed, or do they retain their horizontal position?

A. Some of them have been upheaved, even to the perpendicular, as is the case at the Isle of Wight.

Q. Do not London and Paris stand on Eocene deposits?

A. They do; and both contain among their layers beds of plastic clay; that of London is of a coarse description, but that found in the Paris basin is of the fine kind, from which porcelain is made.

Q. Is this the principal difference between the two beds?

A. By no means. The contents of the London basin are principally argillaceous, while in that of Paris calcareous beds predominate, mixed with important beds of gypsum and silicious matter.

Q. What is the character of the Eocene where it occurs in our Southern States?

A. The beds so much resemble the Cretaceous beds of New Jersey, that they have frequently been assigned to the chalk.

Q. What proves their being Eocene deposits?

A. The character of their fossils, an examination of which immediately fixes their position.

Q. What has rendered the Paris basin so peculiarly interesting?

A. It is so both from its fossils and the fact that some of these remains first drew Cuvier's attention, and induced him to reconstruct the strange forms that had here lain down to die long ages before man's creation.

Q. What is the size of the Paris basin?

A. The depression in the Chalk, which is filled by these beds, is 180 miles long, and about half as broad.

Q. What is the appearance of the chalk where these beds overlie it?

A. The Chalk offers every appearance of a surf-beaten reef, which it probably was before the Tertiary age, being much broken up, and covered by flints rolled over its surface, and glued together by a silicious compound.

Q. Where else does the Eocene occur?

A. It presents itself in almost all the countries of Europe, in Asia Minor, India, Egypt, North and South America.

Q. Are the Eocene fossils abundant?

A. They are both numerous and varied. The Ammonite and Belemnite have both disappeared, but the greatest and most interesting variety of shells is found.

Q. Are any of these shells large?

Fig. 42.

Cerithium cinctum; Paris and London Basins.

A. The smaller and microscopic creatures had increased greatly, and small shells were far the most numerous, yet some species were very large. The Cerithium Giganteum, for example, some of which are twenty-seven inches in length.

Q. Is the Cerithium an interesting family?

A. Yes. It is a very large family, comprising upwards of 200 discovered varieties (fig. 42). Some limestone beds are so nearly composed of their remains as to be called Cerithia limestone.

Q. Was the Nummulite found in the Tertiary beds?

A. Very large deposits of that shell also occur in this system.

Q. What other fossils occur?

A. The remains of crabs and fishes are very abundant.

Q. What is Monte Bolca, in Northern Italy, celebrated for?

A. For its immense stores of fossil fish, several hundred species of which have been taken from it.

Q. Are these specimens in good state of preservation?

A. So perfect are these fish in every part, that it is supposed they must have been destroyed and entombed at the same moment.

Q. How could that be?

A. It is supposed by the rushing of liquid limestone into the ocean from a neighboring volcano.

Q. From which of the deposits of the Paris basin were the bones, that Cuvier commenced his labors on, taken?

A. From the Gypsum. It was here that the greater number of the Eocene quadrupeds were discovered.

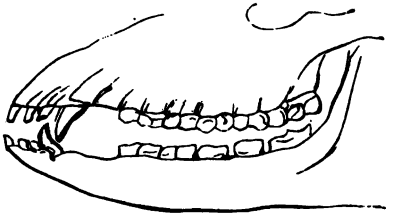
Q. What do these animals most resemble?

A. They all, more or less, approach to the Rhinoceros and Tapir. Animals that belong to the order Pachydermata (thick-skinned).

Q. Describe some of these.

A. The Palæotherium (fig. 43), from ancient and wild beast, was very like the present tapir. Twelve species have been found, varying in size from that of a small hog to the rhinoceros. It had a short proboscis.

Fig. 43.

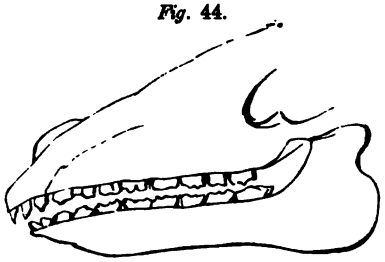


Jaws and teeth of Palæotherium magnum. (One-sixth natural size.)

Q. What was the Anoplotherium?

A. The Anoplotherium (fig. 44), (defenceless wild beast), so called from having no tusks, is an extensive genus much resembling the Palæotherium.

Fig. 44.



Jaws and teeth of Anoplotherium commune. (One-sixth natural size.)

Q. What number of species have been taken from the Paris basin?

A. More than twenty species of extinct Mammals have been found there. A great number, when we take into consideration the limits of the basin, the very imperfect examination that can be made of the contents of any bed, and the small proportion of bones that have been preserved till our time.

Q. In what condition are the bones found?

A. The bones of the larger animals in this basin are much scattered, and it required great patience and skill to collect and reconstruct them.

Q. Was not this the case also with regard to the smaller animals?

A. The smaller ones frequently have one side quite perfect, while of the other there is not a vestige.

Q. How is this to be accounted for?

A. It can only be explained by supposing the gypsum to have been of a soft consistence at the time the animals died, that the stationary bodies gradually settled a short distance, and the bones thus supported were preserved, while the others crumbled, or were dragged to a distance.

Q. In what condition are the bones found in the English Eocene?

A. In the English Eocene the bones are all of the most

fragmentary character, but the great skill of Professor Owen has enabled him to ascertain they are identical with those of the Paris basin.

Q. What number of species of Mammalia have been found in the Eocene?

A. Between fifty and sixty; among them are a number of carnivorous quadrupeds.

Q. Are any of these of the same genera with living Carnivora?

A. Of the same genera, but not the same species. There were the wolf, fox, raccoon, &c. The bat made its appearance in this epoch, and increased greatly.

Q. Were monkeys introduced in the Tertiary beds?

A. Their remains have been discovered in the Tertiaries of England, Germany, France, India, and Brazil, proving a wide diffusion of an animal now confined to very warm climates.

Q. What were the insects of this period?

A. They were numerous, and are beautifully preserved.

Q. Are there many specimens of fossil resin in the Eocene?

A. Quantities of fossil resins are found, of which Amber is the most beautiful and valuable.

Q. What system of mountains is referred to this period?

A. The System of the Pyrenees.

CHAPTER XXI.

MEIOCENE.

Q. Describe the Meiocene or Middle Tertiary period?

A. During the second Tertiary period both terrestrial and aquatic animals increased, and became more like our present races.

Q. How is the Meiocene represented in England?

A. By thin and gravelly strata, called the "Crag Formation."

Q. Where does it appear in Europe?

A. In Europe it fills up many of the river basins, the great valley of Switzerland, extensive plains in Hungary, Poland, and Russia; it appears also on the shores and islands of the Mediterranean.

Q. What do the Meiocene strata consist of?

A. Of quartzose sandstone, shelly limestone, marls, lignite, and corals.

Q. Are there many shells in the Meiocene?

A. Though this formation abounds with shells, it does not possess as great a variety as the Eocene; still, the advance in form is marked, as eighteen per cent. belong to the Modern Age.

Q. Are any of its large animals like those of the Eocene?

A. Several species of Palæotherium are found here, differing from those of the Lower Tertiary.

Q. Did not the great Mastodon make its appearance in this formation?

A. The bones of the Mastodon (frontispiece), are found in Europe in this formation, but in America it has not been found earlier than the later Tertiaries.

Q. What is the most remarkable animal of the Meiocene?

A. The crowning wonder of this period, and, as far as yet known, the most enormous quadruped that ever yet lived on the globe, is the strange Dinotherium (fig. 45).

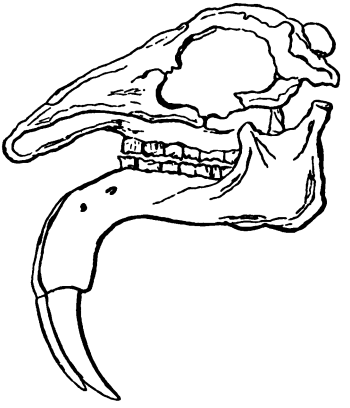
Fig. 45.

The Dinotherium.

Q. Describe this animal.

A. The lower jaws were fully four feet long (fig. 46), and terminated in stout bent tusks, turned downwards, apparently for grubbing; the head was three feet across, it was aquatic in its habits, and seems a connecting link between the whale and the elephant.

Fig. 46.



Cranium and jaws of Dinotherium giganteum. (One-thirtieth natural size.)

Q. Have not many fossils been brought from India?

A. The Sewalik Hills,

or Lower Himalayan Range of India, have rich stores of mammalian remains. The most curious animal as yet discovered there is the Sivatherium.

Q. Describe it.

Fig. 47.

Skull of the Sivatherium giganteum; from the Sub-Himalayas. (One-fourteenth natural size.)

A. It was about the size of a rhinoceros, with a large head, shaped like the elephant's (fig. 47), but with two sets of horns, one like those of the ox, placed over the eyes, and the other probably palmated, like the elk's, were on the back of the head.

Q. Had it any other peculiarities?

A. Like all the Pachyderms of the period, it had a short trunk. It seems to establish a link between the pachydermata and ruminantia, an order not yet introduced.

Q. What was the Toxodon?

A. This was a pachyderm of South America, so called from the shape of its gnawing teeth, the name being derived from Greek words, signifying bow and tooth; it was a powerful animal.

Q. Do not the horse and pig occur in these deposits?

A. They do; and though domestication greatly alters the forms of animals, Cuvier could recognise no difference between the fossil horse and the living species.

Q. What was the character of the Meiocene flora?

A. Such as to prove the still tropical character of the climate of quite high latitudes. The Palms, which cannot now exist north of Africa, are in these strata scattered over Europe.

Q. Did the flora as well as the fauna show an increasing resemblance to modern species?

A. The dicotyledonous plants greatly increased, and among the remains of Conifers which form the mass of the lignite, we find abundant evidence of a higher vegetation, while the clays which accompany it abound in leaves belonging to the Maple, Elm, Walnut, Birch, &c.

Q. Are any of the seeds or fruit of these plants found?

A. Quantities are found as fossils, which we can hardly distinguish from those we pluck from living trees.

Q. Is there any Meiocene coal?

A. No regular coal seams have been found, but the Meiocene flora has left its traces in large beds of lignite and combustible earth.

Q. Are any mountain systems assigned to this epoch?

A. The System of Corsica is placed at this age.

CHAPTER XXII.

PLEIOCENE.

Q. Describe the Pleiocene in England.

A. The Pleiocene is composed of beds of sand, gravel clay, and loam, with flinty shingle and chalk.

Q. What are its fossils?

A. It contains a few zoophytes, and is rich in marine shells; nearly a hundred varieties of mollusks have been obtained from it, of which about twenty belong to the

land or fresh-water. The remains of fishes, mammals, and birds are also found.

Q. What is the representative of the older Pleiocene in England?

A. The only representative of this formation in England is the Mammaliferous or Norwich Crag.

Q. What is the character of the Pleiocene of Italy?

A. The beds of this formation, which are near Parma, in Italy, are very thick, and highly fossiliferous; they consist of different colored marls, and are covered by thick sandy beds. They also lie on both sides of the Apennine Mountains, from which they have been termed Sub-apennine.

Q. What is remarkable in the German beds?

A. They are conspicuous for the quantity of brown coal they afford. These lignites lie between clay and sand beds, and the wood is so little changed as sometimes to be used for timber. Similar kinds of trees still grow in the surrounding country.

Q. What fossils have been attributed to this period?

A. Fossil camels have been found in Siberia, France, Asia, and South America. The Camelopardalis, or Giraffe, which is now confined to Africa, had its origin in this remote period, the remains of a small extinct species having been found in France.

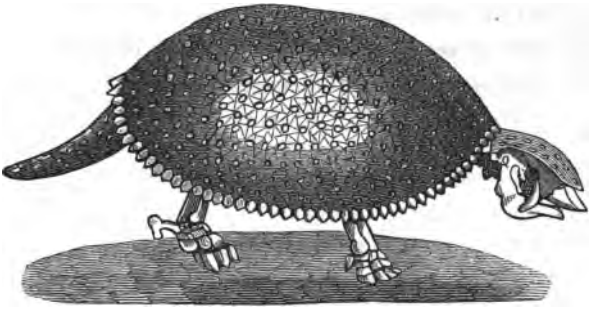
Q. What was the Glyptodon?

A. A gigantic edentate (without teeth) animal (fig. 48), allied to the Armadillo; it belongs to this period, and is only found in the Pampas of South America.

Q. Describe it.

A. It was clothed in a complete suit of armor, com-

Fig. 48.



Glyptodon clavipes.

posed of a vast number of plates, beautifully fitted together. The structure of the hind foot is very peculiar, being wonderfully adapted to support its enormous weight, and allow the free motion of the fore limbs, which the habits of the Armadilloes require.

Q. Are other animals of a similar construction found in the Pampas?

A. Yes. The remains of extinct genera, and species of the Ant-eaters, are also found there.

Q. What is the Scelidotherium?

A. This creature is a link between the Ant-eaters and Armadilloes and the Megatherium, an extraordinary animal, which appeared later.

Q. Describe the Scelidotherium.

A. The name, which comes from two words, meaning thigh and beast, refers to its great peculiarity, which was the enormous disproportion between the fore and hind quarters. Its length was not greater than that of a Newfoundland dog, yet the hinder extremities rival

those of a hippopotamus, an arrangement, doubtless, most suited to its habits.

Q. What system of mountains belongs to this period?

A. The system of the Western Alps.

CHAPTER XXIII.

PLEISTOCENE.

Q. Describe the Pleistocene.

A. This formation embraces deposits of eminently fossiliferous sands, marls, and gravels; their fossils belonging almost entirely to living species.

Q. How do they show themselves in England?

A. In beds of a very limited extent. The marine deposits of the Clyde and Glasgow, and the fresh-water of the Thames, belong to this formation.

Q. Are they found in Germany?

A. They are; and are very extensive in Southern Europe, Asia, and America.

Q. Is there not a difference among geologists as to the application of this name?

A. Yes; some give this name only to beds formed after the drift.

Q. Why does not this form a suitable boundary?

A. The drift is confined to high northern and southern latitudes, and where it does not occur, the Pleistocene accumulations present an unbroken series to the alluvial or modern deposits. There seems, therefore, no reason

for not keeping the same name throughout the formation.

Q. Are lignites found in the Pleistocene?

A. These deposits contain frequent masses of lignite, which, in some localities, are worked to advantage.

Q. What is the appearance of these masses?

A. Some indicate tranquil deposition in lakes, others that the plants and timber were brought together by rivers or currents.

Q. Is there not a Pleistocene deposit at the mouth of the Potomac?

A. There is, and the fossils embedded in it are identical in character with the species now living on the neighboring sea-coast.

Q. Are there any other similar beds in our country?

A. Such beds occur in Kentucky, at Niagara, and elsewhere.

Q. What was the general character of the Pleistocene deposits?

A. They may be considered as generally lacustrine.

Q. Does the earth appear to have been populous in this period?

A. It seems to have teemed with life, in genera belonging to the present age and species frequently identical.

Q. Mention some of these.

A. Hyenas, cave bears, elephants, like the one found in Siberia, fitted by its warm covering for a cold climate, mastodons, hippopotami, and rhinoceroses.

Q. Are these creatures identical with the living ones?

A. The genera are modern, but they are all extinct as species, probably owing to the convulsion, which, elevating the principal chain of the Alps, and giving Europe its present configuration, appears to have destroyed many of the land animals.

Q. What was probably the aspect of the world at this time?

A. The general appearance of hill and dale, in its outline and vegetation, must have been much that of our time, though all that is most important to man was only introduced at the latest change.

Q. Mention some of these, the last introductions.

A. The fruit-bearing shrubs and trees, which afford us so much enjoyment as well as nourishment, and the various kinds of grasses, including the cereals, without which human life could hardly be supported, as well as some of our most valuable domestic animals.

Q. Mention some of the most conspicuous animals of this period.

A. The gigantic Megatherium has been disinterred from these beds in South America, where, even to a greater extent than in North America, a type more antique than that of Europe still prevails; it has also been found in the later Tertiary beds of Georgia.

Q. Describe the Megatherium.

A. This extraordinary quadruped (fig. 49), presents a

Fig. 49.

The Megatherium.

striking resemblance to the Sloth; in height it nearly equals the elephant, being eight feet high, twelve feet

long, and five feet across the loins. The head was small in comparison with the body, and the mouth was an organ of immense power, with teeth admirably fitted for grinding. It probably fed on roots.

Q. Mention some of the peculiarities of this creature.

A. The thigh-bone of the Megatherium is nearly three times as large as that of the largest elephant; and the vertebræ of the tail so much exceed in proportional size those of any known animal, it is supposed the hind legs and tail formed a species of tripod, by which the creature was sustained when the forelegs were digging, or bearing down a tree, which they were well adapted for grasping.

Q. Was there anything peculiar in the foot?

A. The heel-bone projects backward about 18 inches, while the small bones advance forward as much. The third toe has a socket for a claw, the sheath of which is 13 inches in circumference, and the core to which the nail was attached is 10 inches long. The whole structure is an unequalled specimen of colossal mechanism.

Q. Are there any other animals of this description?

A. The Mylodon (fig. 50), also from South America, is of the same genera, and is an enormous animal, though not equal to the Megatherium. Bones of the Mylodon have been taken from Tertiary beds in Georgia. Various other members of the family have been found.

Q. What system of mountains belongs to this epoch?

A. The System of the principal Alps.

Fig. 50.

Mylodon robustus.

CHAPTER XXIV.

QUATERNARY.

Q. The Tertiary period being completed, describe the Quaternary.

A. The Quaternary period, commencing with the drift, runs down to the present day.

Q. Do all geologists keep this classification?

A. English geologists generally discard this division, and bring the Tertiary down to the Alluvium.

Q. What would bear them out in rejecting what is called the Diluvium, as indicating an epoch?

A. In some places, as in South America, the Pleistocene presents an unbroken series to the present formation; yet the great drift and boulder epoch seems too important to be looked upon as a mere variation in an era.

Q. What seems to render it proper to look upon it as constituting the beginning of a new era?

A. It seems to have been the mode taken to usher in the age of man, and classing it with that age itself seems the best arrangement.

Q. How is the Quaternary divided?

A. Into Diluvium and Alluvium.

Q. Describe the Diluvium.

A. The Diluvium embraces the drift and boulder period, and is composed of sand, gravel, clay, pebbles, and fossils, which have been transported from their original localities, and scattered abroad.

Q. What is the meaning of the name?

A. It is from a Latin word, meaning to wash away, and signifies that water has been the agent by which these masses have been transported.

Q. Is the Diluvium or Drift universal?

A. It is not; none has ever been found in the torrid zone. It rarely comes lower than 40 degrees north latitude; it has been traced in Patagonia to about 41 degrees south latitude. The great central belt of about 80 degrees is either entirely free from its effects, or they are exhibited in such modified forms as not to be recognised.

Q. Has this formation excited much interest?

A. Great and increasing interest is excited as its phenomena are becoming more known, and several theories have been proposed to explain them.

Q. Is there general agreement on any point?

A. It seems generally conceded that ice has been the moving agent, but whether only as modern icebergs act, or in a more extended and glacier-like form, will need greater research to determine.

Q. Has the Drift produced any accumulations of fossils?

A. To the Diluvial Drift is referred the collections of bones in the frozen ocean near Siberia, and on the northern shores of that desolate region.

Q. Are these collections of any amount as to the quantity or varieties of animals?

A. The bones of countless numbers of stags and horses, elephants and rhinoceroses, and other animals, are found there.

Q. Is any use made of these bones?

A. The ivory obtained from these relics of an extinct creation competes fairly with that of the modern elephant, and is in sufficient quantity to constitute a distinct traffic.

Q. As none of the existing species of these genera can support life in a cold climate, what must we infer from such vast accumulations in that latitude?

A. We infer two things: that the animals themselves differed from those of the present time in their power of enduring cold, and that the climate was much milder than it is at present.

Q. What grounds have we for such an inference as to the animals?

A. Specimens preserved to a recent date by the ever-

frozen masses of sand in which they were entombed, were covered by a coarse, long hair, concealing a short, thick, woolly fur.

Q. Upon what grounds do we decide as to the change of climate?

A. Those immense herbivorous animals require an amount of vegetation for their support that could only be procured in a genial climate, and the existence of palms in Europe down to this period proves such to have existed in what is now a truly cold region.

Q. To what cause are the boulders to be attributed?

A. The Boulder or Erratic Block period is probably to be attributed to the same cause, or succession of causes, which formed the Drift.

Q. Of what size are the boulders?

A. They are of all sizes; from moderate fragments of rocks to masses weighing thousands of tons, and are in some places scattered quite thickly over the surface.

Q. From what distance are they usually brought?

A. Sometimes they appear to have been transported hundreds of miles from their original places; more usually, however, they are removed but a few miles from the rocks from which they have been broken.

Q. Where do these boulders occur?

A. Almost the whole of the northern part of North America seems to be covered with these boulders, sand, and gravel. Erratic blocks are scattered over Central Europe and the Steppes of Russia. A great part of the plain of Switzerland is covered by fragments of rocks, measuring about a cubic yard; they strew the valleys, and rise on the mountain sides many thousand feet above the surface of the sea.

Q. Did not the transportation of such masses produce lasting results?

A. The motion of such heavy masses has of course left deep traces on the rocks over or by which they passed; they are sometimes scratched or grooved to the depth of a foot. In some places the surface of the rock is smoothed, as if it had been done by a stonecutter.

Q. Are these marks ever observed at considerable elevations?

A. In the White Mountains these striæ are found five thousand feet above the ocean.

Q. Is the form of the hills ever affected by the passage of these masses over them?

A. They are sometimes worn into a rounded or elongated shape, forming what the French call "Roches Moutonnees." In many places the hills are capped by these deposits.

Q. What is supposed to have been the direction of the Drift currents?

A. The general direction of the Drift is from north to south, occasionally diverted by mountains. In Europe it appears to have proceeded in different directions from the Scandinavian Mountains.

Q. Are the boulders ever arranged as if left by a current?

A. Yes; there are in some places regular streams of stones, affording an argument for the glacier theory.

Q. What parts of our country are specially marked by this period?

A. The borders of Lakes Erie and Ontario are strongly marked by the Great Drift, and Ohio has vast numbers of boulders scattered over its surface, becoming smaller and fewer as you go south.

Q. What is the character of the blocks scattered in Switzerland?

A. These thickly-scattered masses, which are most abundant near Neufchatel, and which are also found lying on the steep slopes near Geneva, and some of which are of enormous size, are of an entirely different rock from the formation they rest on.

Q. Have we reason to date any important change at this epoch?

A. Whatever produced these strange appearances, we have reason to think the present climatal relations of different parts of the globe were then effected. Palms ceased to grow in Europe at this era.

Q. Was there an equal change in the European fauna?

A. There was; the elephant, rhinoceros, hyena, &c., disappeared from her soil entirely; her fauna and flora changed, and rendered identical with the present, the conclusion of this period may have been the epoch of man's introduction. All relics of him are found in the later or now-forming deposits.

Q. Do any mountain systems date at the Quaternary?

A. The last which can be termed a system, called the System of Tenare, dates at this time.

Q. Have elevations entirely ceased?

A. By no means; either in the form of mountains, islands, or upheavals, sometimes rapid, more frequently very gradual, of whole districts, but they have not been on as extensive a scale, or marked by such general disturbance of the surface as appears to have characterized volcanic action in past epochs.

CHAPTER XXV.

CAVERNS.

Q. Describe caverns.

A. Caverns are but fissures in limestone rocks, generally more or less increased by the action of water. They are principally interesting in a geological point of view from the fossils they contain.

Q. Have many fossils been taken from caves?

A. In some of them such vast numbers of bones have been found that they are distinguished as "bone caverns."

Q. Where have they been found?

A. Those of the Harz and Franconia are very famous, some interesting ones in South America have been discovered, but the Kirkdale Cavern of England (fig. 51), is perhaps one the most generally known in our country.

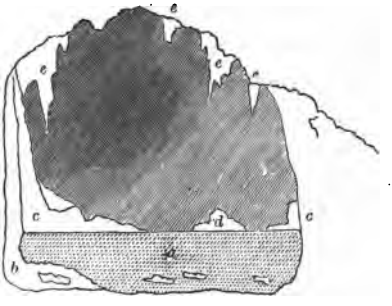
Q. Is it supposed there are many such caves?

A. Since Dr. Buckland has shown the necessity of removing the superficial coverings of the floors of caves, even to a considerable depth, when fossils are searched for, these remains are almost always met with, even in places where, until such search was made, no indication whatever of them existed.

Q. What is supposed to be the cause of these accumulations?

A. Many of these caverns had several lateral openings, and therefore were desirable retreats, age after age, for beasts of prey, who sought them as places of refuge

Fig. 51.



Section of Entrance to Kirkdale Cave.
(Four feet.)

a, Mud covering the floor of the cave to the depth of one foot, and concealing the bones.
b, Stalagmite, containing bones, formed before the mud was introduced.
c c, Stalagmite formed over the mud.
d, Insulated Stalagmite on the surface of the mud.
e e, Stalactites dependent from the roof.

when wounded and dying, and made dens of them, to which they carried their prey while living.

Q. What kinds of animals are generally found in these caves?

A. Of the Carnivora that made these caves their dwelling-place, bears and hyenas are the most numerous. The hyena, which is now exclusively an inhabitant of warm climates, was at one time very numerous in England and Europe.

Q. What have been found in the Kirkdale cave?

A. Between two and three hundred skeletons of hyenas, mingled with occasional remains of the cave-bear, the cave-tiger, the wolf, and fox. The remains of other animals occur in great numbers, such as the rhinoceros, hippopotamus, horse, deer, ox, hare, rabbit, water-rat, mouse, &c., with the bones of a very young mammoth, and many kinds of birds.

Q. Is there any depth of such deposits?

A. They cover the floor to the depth of several feet, and show that for many ages these ferocious beasts must have sheltered themselves, and devoured their prey, in its recesses.

Q. Describe this cavern.

A. Its mouth is but about four feet each way, and must have been entirely closed up by the Drift deposit, which secluded it from light and air, until about thirty years back, when workmen engaged in the neighboring quarry broke into one of its sides.

Q. Are the German caves more or less extensive than this?

A. Some of the caverns in Germany far exceed in size, and the amount of fossils they contain, that of Kirkdale. That of Gaylenreuth (fig. 52), which has been known for

Fig. 52.

Vertical section of the cave of Gaylenreuth.
a, Entrance to the cave. *b*, One of the deep recesses.

nearly a century, has yielded to various museums and collections wagon-loads of bones.

Q. Did Cuvier examine the bones from Gaylenreuth?

A. He did, and pronounced that at least three-fourths of them belonged to different species of bears. The bones not belonging to the Carnivora frequently show traces of teeth, proving the flesh has been gnawed from them.

Q. What is osseous breccia?

A. Fragments of bones, mingled with clay, pebbles, &c., cemented together by Carbonate of Lime or Iron, are frequently found in fissures of rocks; these accumulations are called osseous breccia.

Q. Is this breccia composed of living or extinct species?

A. Of both commingled. The bone breccia of Australia yields only the remains of Marsupials, or pouched animals, which still form the chief characteristic of its fauna.

Q. Describe the Alluvium.

A. This includes all deposits since the Drift period, and those which are now progressing.

Q. Of what are these deposits composed?

A. Of sands, gravels, clay, marls, vegetable and animal matter.

Q. Is the Alluvium deep?

A. In favorable situations, such as where a large river forms a delta, or extensive beds of peat mosses occur, which sometimes cover hundreds of square miles, the Alluvium will reach the depth of forty or fifty feet. Ordinarily it is but a shallow deposit.

Q. What are the plants of the Alluvium?

A. They all belong to existing species. In Scotland, at the depth of twelve feet, a quantity of hazel-bushes, nuts, bones of deer, an English coin, and oars of a boat,

were dug up. The bodies of men, known from their dress to belong to tribes extinct for centuries, have been found deep in the peat swamps.

Q. What are the animals of the Alluvium?

A. The animal remains of the Alluvium either belong to the existing or very recently extinct species.

Q. Are solid rocks forming in the Alluvium?

A. They are probably forming at the present time as rapidly as at any past epoch. Mr. Lyell says that a hard stratum of travertine, a foot in thickness, is made in the course of four months by the waters of San Filippo, in Italy, and from various causes similar consolidations are going on in different parts of the globe.

Q. Are igneous rocks being formed?

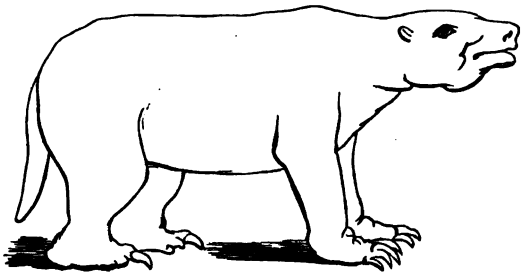
A. The active volcanoes frequently throw up large quantities of lava, which overflow the surrounding country, changing its appearance and character.

Q. What will probably be most conspicuous among modern masses?

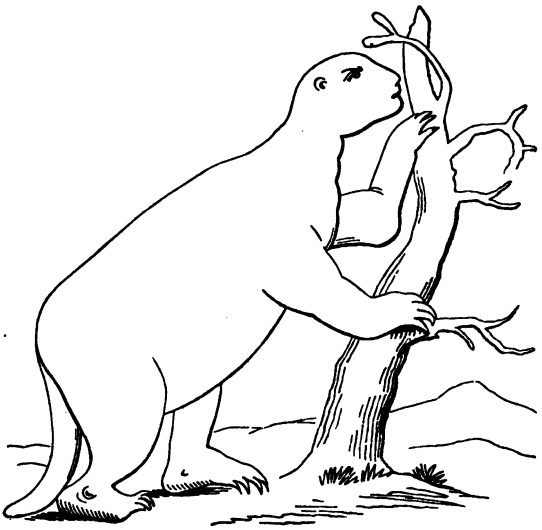
A. Those formed by the smaller organisms, such as corals, microscopic creatures, and some of the smaller marine shells.

Q. When we reach the Alluvium, has the geologist arrived at the extremity of his field?

A. He has; the appearance of the globe as it is, with its living animals and plants, belongs to the Physical Geographer and Natural Historian.



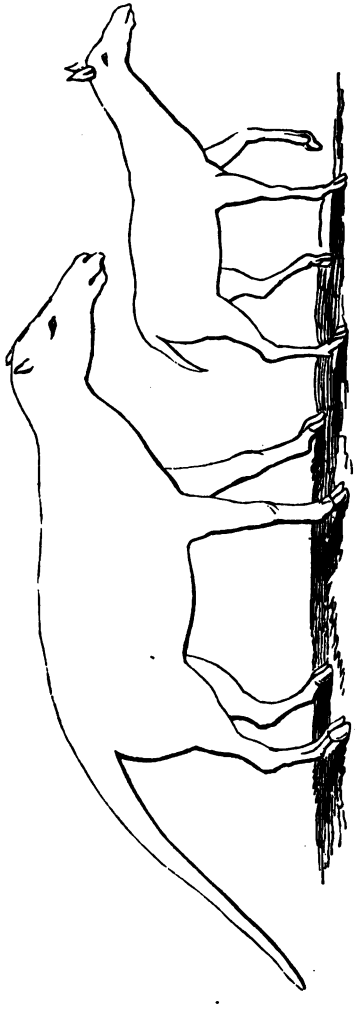
Megatherium.
South America.



Mylodon robustus.
South America.

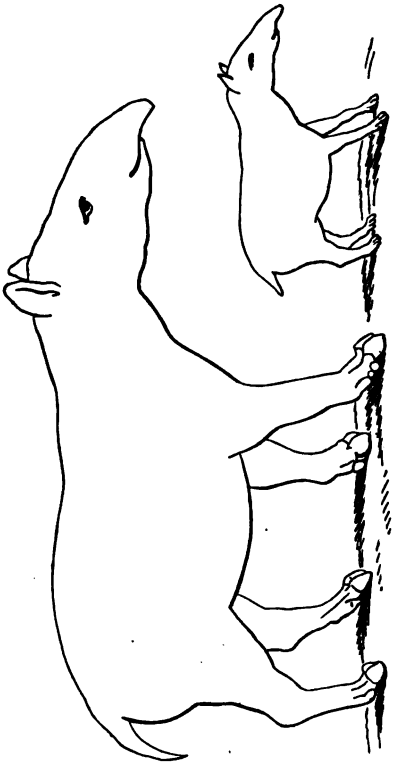
Sivatherium.
Sewalik Hills, India.

Dinotherium.
Valley of the Rhine.



Anoplotherium commune. Anoplotherium gracile.

From Mont Martre, near Paris.



Paleotherium magnum. Paleotherium minus.
From Mont Martre, near Paris.

NOTES.

Note *a*.

The volcanic history of Iceland is more perfect than that of any other region of volcanic activity on the globe, with the exception of Italy. We are in possession of records of its successive convulsions from the ninth century to the present time. There is probably no portion of the earth where volcanic action has been so uninterruptedly exhibited, there never having been a longer interval than forty, and seldom more than twenty years between the great earthquakes and eruptions; while powerful hot springs, jets of sulphurous smoke, subterranean sounds and tremors of the earth, give constant evidence of the ceaseless activity of the fearful agents below. Many cones have been thrown up, and small islands brought to the surface in the surrounding ocean, some of which have remained. The year 1783 was distinguished by volcanic displays of a tremendous nature; a submarine volcano burst out, which threw up such immense masses of scoriæ that the progress of vessels was impeded for many miles in its neighborhood. Earthquakes were felt through the whole island, and in June they increased in violence, at which time Skaptaa Jokul, a mountain throned amid perpetual snows and inaccessible precipices, was observed to give indications of volcanic activity. In the course of a few days the river Skaptaa, a stream of considerable size, disappeared, and torrents of lava from the mountain filled its bed, flowing in the rocky channel two hundred feet wide, and in some places from four to six hundred feet deep. In many places overflowing all barriers, the lava spread over the country to a great extent. On its way to the ocean it filled up the bed of a lake and many caverns and abysses, the products of former disturbances. In August a fresh outburst of lava took another direction, and destroying another river in its course, reached the sea at a point nearly ninety miles distant from that where the first current poured itself into the ocean. One of these streams was forty, the other fifty miles long; they flowed towards the sea in nearly opposite directions. The ordinary height of both currents was one hundred feet, but in some chasms they were heaped up to the height of six hundred feet. Where, unconfined by rocky barriers, they spread over the country, they were from seven to twelve miles wide. Thinly settled as Iceland was, having but fifty thousand inhabitants on the whole island, nine thousand lost their lives during these terrific convulsions, which continued for nearly two years. A large amount of the best land of the island was destroyed, and vast numbers of cattle; twenty villages were overwhelmed, besides those destroyed by the overflow of the waters, caused by the blocking up of the outlets of some of the rivers. Iceland has not, and probably never will recover the effect of this awful convulsion. The fearful explosions, the darkness, the rain of ashes, and the mephitic vapors con-

stantly thrown into the air, must have rendered the whole island a fearful abode even for those who were beyond the reach of the lava. The volcano of Kilauea, in Hawaii, the largest of the Sandwich Islands, is always active; and since it has been known to civilized man, numerous eruptions have taken place, during which immense quantities of lava have been discharged. The one which occurred in 1840 almost rivals that of Skaptaa Jokul, as a stream of lava, from one to four miles in width, and from two to ten hundred feet in depth, ran from the crater to the sea, a distance of forty miles, in less than three days; and for three entire weeks, continued with a fearful noise to pour into the ocean, leaping from a precipice forty or fifty feet high. The shore was extended by its accumulation a quarter of a mile, and the waters so heated that the fish were killed for a great distance. So intense was the light that fine print could be read at midnight at a distance of nearly forty miles. Eruptions of great though not equal violence have occurred since, from this mountain and its immediate neighbors.

Note *b*.

The volcanic mountain Tomboro, eight thousand nine hundred and forty feet high, stands near the northern coast of Sumbawa, an island of the Malay Archipelago, east of Java, about one hundred miles long and thirty-nine miles at its greatest width. The famous eruption of this mountain, which took place in April, 1815, agitated to an alarming extent the surface of a district whose circumference is one thousand miles, and the terrific explosions were heard in Celebes, the Moluccas, and Sumatra, a region whose radius is one thousand miles. From Sumbawa to the part of Sumatra where the sound was noticed, is about nine hundred and seventy miles: the greatest distance at which a volcano had been previously heard, according to Humboldt, was six hundred miles. In Java the sounds were so distinct that it was supposed one of their own mountains must be active. In the neighboring island of Lombok many people were buried under the ashes, which destroyed the vegetation so entirely that a famine ensued. In Java, three hundred and forty miles off, they fell to the depth of several inches, and the floating cinders, west of Sumatra, formed a mass two feet thick, through which ships found their way with difficulty. In the district of Tomboro alone (the island is divided into six districts), twelve thousand persons were killed. Another eruption occurred in 1836, but it was much less violent.

Note *c*.

The table in the front part of the book presents the systems of crassification adopted by several of the most distinguished geologists of England and our own country.

Note *d*.

The cypris, a little crustacean, some species of which are living, and may be seen swimming swiftly through stagnant waters, has left countless myriads of its remains in the strata of various epochs, producing in them a

laminated form not exceeding the thickness of fine paper, as is the case in Auvergne, in France, where stratified masses of the exuviæ of these creatures occur several hundred feet thick. The animal resides between two valves, not unlike a bivalve-shell (see fig. 53); its principal organs of motion consist of antennæ and feet. The Hastings sand and Purbeck limestone of England, strata a thousand feet thick, are filled with them. Rapid as is the increase of these minute organisms, countless ages must have passed as the strata slowly piled up from such a source. The Infusoria, so called from their abounding in infusions of vegetable substance, are creatures so minute that most of them require microscopes of the highest power to examine them. They swarm in all kinds of water, in all liquids, even in the juices of plants, and the fluids of living animals in their most healthy condition. They were formerly regarded as merely animated particles; but with the increase of our power of examination, from the improvement of our instruments, has come such an increase of knowledge that we now know these minute creatures to be in reality complex organisms, possessing mouths, teeth, stomachs, eyes, muscles, &c. They increase so rapidly that one individual became in ten days 1,000,000, on the eleventh day 4,000,000, on the twelfth day 16,000,000. Ehrenberg says of another, that it is capable of increasing in four days from one individual to 170 billions. Some of these creatures are enclosed in silicious shields, and have contributed to the earth's crust, forming by their relics large masses of soils, and rocks many feet in thickness, which cover large districts. Ehrenberg considers the Bog iron ochre and the Kieselguhr, of the Alluvial, the polishing slate, or rotten stone, and semi-opal of the Tertiary, and probably the semi-opal of the Dolerite, the precious opal of the Porphyry, and the flint of the Chalk, as resulting from the relics of Infusoria, in a more or less perfect state of preservation. The accompanying table deserves a careful examination; it will probably enlarge the views of the student as to the variety of organisms which have contributed to build up what we term the "solid globe we tread upon," and the number of the strata which are principally composed of them. The list might be much enlarged, as all the vegetable organisms are omitted, which, not merely in the great coal measures, but also in the form of lignite, submerged and silicified forests, fucoid beds, peat, &c., have added much to that crust on which man lives, and from the varied contents of which he must seek his support. Of the elaboration of much of the present calcareous and silicious matter from its former gaseous and fluid state, by means of vital action, positive proof may be wanting, but the evidence of its probability is great. What, after filling our minds with the results of these carefully-conducted investigations, investigations which have yielded so much, and still promise more, what can we do but reverently exclaim, "O, Lord, how manifold are thy works! in wisdom hast thou made them all. The earth is *full* of thy riches."

Fig. 53.

Fossil shell of Cypris, natural size, and magnified.

ROCKS COMPOSED WHOLLY OR PARTLY OF ANIMAL REMAINS.

Strata.	Prevailing organic remains.	Formations.
Graptolite schists	Graptolites	Llandeilo rocks.
Trinucleus shales	Trilobites	Caradoc rocks.
Pentamerus rock	Pentamerus lens, &c.	Llandovery rocks.
Dudley limestone	Corals, brachiopods, bryozoa, crinoids, &c.	Wenlock rocks.
Gothland limestone	Beyrichiæ, brachiopods, corals, &c.	Wenlock rocks.
Navicula band	Cethyris navicula	Ludlow rocks.
Bone bed	Coprolites, fish bones, &c.	Ludlow rocks.
Cephalaspis beds	Fish remains in nodular concretions	Old Red.
Caithness flags	Fish remains and bitumen	Old Red.
Devon marbles	Corals with shells and crinoids	Devonian or Old Red.
Calceola schist	Calceola sandalina and other shells	Devonian or Old Red.
Clymenia limestone	Clymenia, goniatites, with other shells and trilobites	Devonian or Old Red.
Cypridina schist	Minute entromostraca, shells, plants, &c.	Devonian or Old Red.
Coral marble	Corals, brachiopods, &c.	Mountain limestone.
Encrinital marble and shales	Crinoids, brachiopods, &c.	Mountain limestone.
Shell limestone	Brachiopods, foraminifera, &c.	Mountain limestone.
Fusulina rock	Fusulina cylindrica	Mountain limestone.
Fish beds	Teeth and spines of fish, with shells and corals	Mountain limestone.
Mussel bands	Fresh-water shells, such as anthracosiæ, &c.	Coal measures.
Ironstone nodules	Limuli, insects, and shells	Coal measures.
Fish shales	Palæoniscus, &c.	Coal measures.
Zechstein	Foraminifera, entomostraca, bryozoa, corals and shells	Permian.
Muschelkalk or shell limestone	Shells, crinoids, &c.	Trias.
Bone bed	Bones, teeth, and coprolites of fishes, reptiles, and mammals (rare)	Trias.
Ammonite limestone and Ammonite shale	Ammonites	Lias.
Lias rock	Shells and crinoids, with bones of reptiles and fishes	Lias.
Gryphite limestone	Gryphæ and other shells	Lias.
Cephalopoda bed	Remains of ammonites and belemnites, with fish remains	Oolite.
Shelly limestone	Terebratulæ and other shells	Oolite.
Stonisfield oolite	Shells, reptiles, fishes, and insects	Oolite.
Caen stone and Bath stone	Shells, corals, crinoids, reptiles, and fishes	Oolite.
Forest marble	Debris of shells, echinoderms, &c.	Oolite.
Kelloways rock	Ammonites and other shells	Oolite.
Coral rag	Corals, shells, &c.	Oolite.
Nerinæ limestone	Nerinæ and other shells	Oolite.
Portland stone	Terebræ, trigonæ, ammonites, and other shells	Oolite.
Chert and flint	Sponges, &c.	Oolite.
Corbula beds	Corbulæ and other shells	Purbeck.
Cinder beds	Ostraca distorta	Purbeck.
Purbeck marble	Paludinæ and cyprideæ	Purbeck.
Sussex marble	Paludinæ and cyprideæ	Wealden.
Tilgate stone (some beds)	Bones of reptiles and fishes, and fresh-water shells	Wealden.
Lobster beds	Meyeria vectensis	Lower green sand.
Kentish rag	Terebratulæ and other shells	Lower green sand.
Oyster beds	Exogyræ, plicatulæ, &c.	Lower green sand.
Farringdon gravel	Sponges, bryozoa, shells, echinoderms, &c.	Lower green sand.
Ammonite bed	Fragmentary ammonites, with other shells, and crustaceans, wood, &c.	Gault.
Chert and flint	Sponges, shells, &c.	Upper green-sand.

Strata.	Prevailing organic remains.	Formations.
Green-sand	Casts of chambers of foraminifera	Upper green-sand.
Hippurite limestone	Hippurites, radiolites, and other shells	Chalk.
White chalk	Sponges, foraminifera, bryozoa, echinoderms, crustacea, shells, fishes, and some reptiles	Chalk.
Flint	Sponges, &c.	Chalk.
Maestricht chalk	Sponges, forminifera, corals, bryozoa, echinoderms, crustacea, shells, fishes, and reptiles	Chalk.
Faxoe chalk	Bryozoa, shells, &c.	Chalk.
Woolwich shell bed	Melanie, cyrenæ, and other shells	Eocene.
Septaria of the London clay	Remains of nautili, or other shells, of fishes or of mammals, enclosed in concretionary nodules	Eocene.
Nummulite rock	Nummulites and other foraminifera, with shells, fish remains, &c.	Eocene.
Alveolina rock	Alveolina and other foraminifera	Eocene.
Calcaire grossier	Foraminifera, bryozoa, and shells	Eocene.
Gypsum beds of Mont Martre	Bones of mammalia, birds, &c.	Eocene.
Indusial limestone of Auvergne	Cases of phryganeæ, with fresh-water shells	Eocene.
Fish beds of Mont Bolca	Fishes	Eocene.
Œningen beds	Mammals, reptiles, fishes, insects, &c.	Eocene.
Paludina beds of Headon Hill	Paludinæ	Eocene.
Falunian beds of Touraine, &c.	Foraminifera, bryozoa, echinoderms, shells, fishes, &c.	Miocene.
Sub-Himalayan beds	Bones of mammalia, reptiles, &c.	Miocene.
Suffolk crag	Sponges, bryozoa, crustacea, echinoderms, molluska, &c.	Pleiocene.
Bone breccia	Mammalia, and land shells	Pleiocene.
Bermuda limestone	Corallines, corals, serpulæ, shells, crustaceans, &c.	Recent.
Guadaloupe limestone	Human bones, land shells, &c., in a debris of corals and shells	Recent.

GLOSSARY.

Abra'sion. The act of wearing or rubbing off—also substance worn by attrition.

Acale'pha (from Greek, Akalephe, a nettle); Acalephæ is the plural. Name given to a class of marine, radiate animals, on account of the property possessed by most of the species of inflaming the skin when touched by them. The medusa, sea-nettle, jelly fish, &c., belong to this class.

Ace'phala (from the Greek, a, without; kephale, a head). Name of a class of molluscous animals, comprehending those which have no head, as the oyster and muscle.

Al'ga (Latin). Sea-weed.

Al'gæ (plural of Alga). A tribe of cryptogamous plants, which is subdivided into three families: the Phy'ceæ, or submerged sea-weeds; the Lichens, or emerged sea-weeds, and the Byssa'ceæ, or amphibious sea-weeds. The Algæ, or sea-weeds, are flowerless, and have neither proper stems nor leaves; they live in the air, on the surface or at the bottom of fresh and salt water. They are remarkable for their cellular or filamentous structure, into which no vessels enter.

Allu'vion, Allu'vium (Latin, Alluvio, Alluo, to wash). Materials transported and deposited by the action of water.

Alu'mina, Alu'mine (from Latin, Alumen). One of the earths, consisting of the metal aluminum and oxygen. It is the characterizing ingredient in common clay, and is sometimes called pure clay. When moistened with water it forms a plastic mass.

Am'ber (from an Oriental word). A hard, brittle, and generally semi-pellucid substance, tasteless, and without smell, until heated or pounded, when it becomes agreeably odorous. It is highly electrical, and is used in varnish. The color is ordinarily some one of the shades of yellow. It is believed to be a fossil resin of the Middle Tertiary, and to be the product of the Pinus succinifer. Quantities of it are thrown up by the waves on the shores of the Baltic in Europe, at Cape Sable in the United States, and various other places. It occurs in situ near London, and in an extensive clay bed in Prussia, where the peasants term the fossilized wood Amber-wood. Amber is especially interesting to the geologist, as having been the means by which insects and delicate vegetable organisms which had been surrounded by it have been beautifully preserved. In Prussia 800 varieties of insects have been identified in the Amber.

Am'monite (Latin, Cornu Ammonis, from Jupiter Ammon, whose statues were represented with ram's horns). Vulgarly called Snake-stone; it is a univalve shell of the order Cephalopoda. It was introduced in the earliest ages, and many of the strata abound with the remains; several

hundred species have been enumerated. They varied in size, from the fraction of an inch to several feet in diameter. They especially abounded in the Liassic, Oolitic, and Cretaceous seas (see figs. 32 and 33).

Amyg'daloid (from Greek, amygdalon, an almond; eidos, form). Almond-shaped. Applied to certain rocks in which other minerals are occasionally embedded. A variety of Trap containing cavities filled by infiltration, wholly or in part, by different minerals, particularly agates, quartz, calcareous spar, and the zeolites.

Animal'cule (from Latin, animalculum); a minute animal. It especially means an animal too small to be distinguished by the eye without the aid of a magnifying glass.

Animalculæ. Plural of Animalculum.

Anoplothe'rium (from Greek, a, without; oplon, or anoplon, unarmed; therion, beast). A genus of extinct quadrupeds, first discovered by Cuvier in the Gypsum beds under Paris, and so named by him from the absence of tusks, or canine teeth, in which they are the only animals that resemble man. The feet terminated in two toes, and, unlike most of the extinct Pachyderms, it had no proboscis. The genus embraces several groups, differing considerably from each other, and varying from the size of the hare to that of a large deer, which one species greatly resembled. The Anoplotherium commune (fig. 44), was somewhat larger, and had a thick tail, resembling that of the Otter, which probably assisted it in swimming.

Aquat'ic (from Latin, aqua, water). Relating to water; applied to animals which live in water, as fishes; or to such as frequent it, as aquatic fowls. Applied to plants, it denotes such as grow in water.

A'queous. Watery; partaking of the nature of water, or abounding with it; applied to rocks, it means those composed of materials deposited by water. From being invariably found in strata or layers, aqueous rocks are also termed stratified.

Arena'ceous (from Latin, arena, sand). Sandy; having the properties of sand; easily disintegrating into sand.

Argil (from Latin, argilla, clay, formed from Greek, argos, white). In a general sense, clay, or potter's earth, but in a scientific sense, the old name for Alumina, or pure clay.

Argilla'ceous. Of the nature of clay.

Armadil'lo (from Spanish, armado, armed, from being armed with a shell). An animal belonging to the genus Dasypus; the body is enclosed in a horny or bony crust, composed of numerous pieces nicely fitted together, and connected by a membrane which permits the creature to roll itself up in a ball when attacked. They subsist chiefly on vegetable substances and insects. The fossil Glyptodon (fig. 48) was a gigantic Armadillo.

Bary'ta, Bary'tes (from Greek, barus, heavy). An alkaline earth; it is the heaviest of all the earths, its specific gravity being four. It is an oxyde, the basis of which is a metallic substance called barytum. It is generally found in combination with the sulphuric and carbonic acids, forming the Sulphate and Carbonate of Baryta, the former of which is called heavy spar.

Basalt'. A rock of igneous origin, composed principally of Augite and

Feldspar; it is of a dull green, brown, black, or gray tint, having frequently grains of magnetic or titanic iron, or particles of Olivine scattered through it. It constitutes immense masses in some places, frequently assuming a columnar form. It also occurs in veins or dikes, cutting through other rocks.

Batrach'ian (from Greek, batrachos, frog). A name given to those reptiles that resemble frogs in their organization.

Belemnite (from Greek, belemnon, a dart). A genus of the Cephalopods, now extinct, but largely distributed through the Lias, Oolite, and the Cretaceous rocks, where many of the beds are distinguished by their specific forms. They are long, straight, and conical, and are vulgarly called thunder-stones. Some are very small, others ten or twelve inches long, and four inches in circumference. The animal was allied to the Cuttle-fish, and furnished with an ink bag, which in some of the fossils has been found in sufficient state of preservation to manufacture the pigment called India-ink from it. They had an internal horny skeleton (fig. 31), and a testaceous (carbonate of lime and animal matter) shell, formed of numerous air-chambers, piled on each other, and traversed by a siphon. Its eyes were large and prominent, and the beak horny and powerful.

Bitu'men. A variety of inflammable mineral substances found in the earth. The varieties appear to pass into each other, from Naphtha, the most fluid, to Petroleum, a viscid fluid; Maltha, more or less cohesive; elastic bitumen, or mineral caoutchouc, and Asphaltum, which is sometimes too hard to be scratched by the nail. They all give out a strong, disagreeable odor.

Bitu'minized. Converted into bitumen.

Boul'ders. Erratic blocks. A term used for rounded masses of any rock found out of place. Generally supposed to have been originally moved and worn by the action of water.

Brack'ish. Somewhat salt; it is applied to any water partially saturated with salt.

Cala'mite (from Greek, kalamos, a reed). A very common fossil of the coal strata. It was cylindrical, gradually tapering to a point, deeply ribbed along its whole length, and crossed by horizontal rings at unequal intervals. It was a branching plant with a hollow stem, woody tissue, and thin bark (see fig. 23). It is supposed to have resembled the modern Equisetum, or horse-tail, more nearly than anything else, yet it reached the size of a forest tree, and presents in its internal structure some of the characteristics of the Conifers.

Calca'reous (from Latin, calx, calcis, lime). Partaking of the nature of lime. Applied to rocks, and other substances of which lime is the base.

Camel'opardalis (from Greek, kamelos, a camel; pardalis, a leopard). The ancient name of the Giraffe.

Car'bon (from Latin, carbo, charcoal). A chemical element, or undecomposed body; it is pure, and crystallized in the diamond. It is the basis of all the varieties of mineral coal, of Graphite, commonly called Plumbago, or black lead, of all animal and vegetable charcoal, and is one of the principal ingredients of all organic bodies.

Car'bonate. A compound of carbonic acid with a base, as Carbonate of Copper. Carbonate of lime forms chalk, limestone, marble, &c.

Carbonif'erous (from Latin, carbo, coal; fero, to bear). Producing or containing carbon, or coal. This term is applied to the strata which contain coal, and to the period when the coal measures were formed.

Carni'vora (from Latin, caro, flesh, voro, to eat); flesh-eating. A family of the Mammalia.

Ceph'alopod (from Greek, kephale, head; podos, a foot). A molluscous animal, characterized by a distinct head, surrounded by a circle of long arms, by which it crawls and seizes objects. The Sepia or cuttle-fish is one of these animals. The name Cephalopod alludes to the fact that the feet or arms are arranged about the head, and appear to proceed from it.

Ce'phalopo'da (Latin plural). Cephalopods.

Ce'real (from Latin, ceres, corn). Applied to the grasses which produce the bread corns, as wheat, rye, barley, oats, maize, rice, and millet.

Ce'rithium (from Greek, keritos, waxen). A genus of univalve mollusks, both recent and fossil. They existed in such numbers in the Tertiary period that some limestones are almost entirely composed of them, and are called Cerithia limestones. The number of species was very great; 137 species have been found in the Paris basin. The size varied from very small shells to the Cerithium Giganteum, which is sometimes 27 inches long (see fig. 42).

Ceta'cea (from Greek, ketos, a whale). Vertebrated Mammalia, living in the water, but not fishes.

Coke. Fossil coal, after its bitumen, sulphur, or other extraneous or volatile parts have been driven off by heat.

Conglom'erate (from Latin, conglomero, to keep together). Any rock composed of water-worn fragments cemented together by another mineral substance, either calcareous, silicious, or argillaceous, as breccia is a term to describe a similar aggregate of uneven and angular materials. The "Great Conglomerate" is the name of a portion of the Old Red Sandstone formation.

Co'nifer (from Latin, conus, a cone; fero, to bear). A plant bearing cones.

Conif'era. An order of plants whose seeds are contained in cones, or have dry, hard, scaly seed-vessels, like the pine, fir, cypress, &c.

Conif'erous. Bearing cones.

Cop'per. A metal of a dingy red color; next to gold, silver, and platinum, it is the most ductile of the metals; it is the most sonorous of the metals, and the most elastic, with the exception of steel.

Co'prolites (from Greek, kopros, dung; lithos, stone). Fossil excrement of animals.

Cor'al (from Greek, koreo, to ornament, als, the sea). A hard, calcareous substance, formed by secretion by certain polyps. It is in regard to them what the skeleton is to the higher orders of animals. Corals have often the form of trees and shrubs, or assume hemispherical and nodular shapes. Such are madrepores, astreas, and brain coral. The surface is usually covered by radiated cells, each one of which marks the position of one of the

polyps. The corals are generally white, but the polyps are of various colors, and when alive present a beautiful appearance. The precious coral is red, and is occupied by a blue polyp.

Cor'rugated. Wrinkled; folded up into wrinkles.

Cre'ta (Latin). Chalk. (See page 80).

Creta'ceous (from Latin, creta, chalk). Of the nature of chalk, relating to chalk. The Cretaceous system is a geological series of rocks in which calcareous matter predominates; the flints, and other extraneous minerals, being subordinate. It is a marine deposit.

Crinoi'deæ (from Greek, crinon, lily; eidos, resemblance). A family of radiated animals, related to some of the star-fishes and asterias, but growing on long-jointed stems. The Encrinites, often called stone lilies, are included in this class, which is represented by numerous species through all the formations.

Crusta'cea (from Latin, crusta, a hard covering). One of the classes of Articulata, or articulated animals, including lobsters, shrimps, and crabs; so called from the crust-like shell with which the body and legs are covered.

Ctenoi'deans (from Greek, ktenos, a comb). The third order of fishes established by Agassiz, characterized by a skin covered with jagged or toothed enamelled scales (see fig. 17).

Cu'bic. Having the form or properties of a cube. A cube in geometry means a regular solid body, with six equal square sides, and containing equal angles: a cubic foot of water is the water that may be contained within six equal sides, each a foot square.

Cyca'dea. An order of plants holding an intermediate place between palms, ferns, and the pine tribe, or coniferæ, but approaching nearer to the last. The fossil genera are not found in any number before the Oolite, when they appear to have increased greatly.

Cy'cas. Meaning a small palm, and given as the name of a genus of tropical plants.

Cycloi'deans (from Greek, kuklos, a circle). The fourth order of fishes, according to the arrangement of Agassiz, having smooth scales (see fig. 17), as the herring and salmon.

Debris (from the French); wreck, ruins, remains. In geology it is applied to a collection of the larger fragments of rocks and strata, to distinguish them from detritus, or those which are pulverized.

Dicotyle'donous. A grand division of the vegetable kingdom, applied to plants having two cotyledons, or seed lobes.

Dilu'vium (from Latin, diluo, to wash away). In geology, a deposit of superficial loam, sand, gravel, pebbles, &c., caused by ancient currents of water.

Dinothe'rium (from Greek, dinos, circular; therion, wild beast). An enormous pachyderm of the Middle Tertiary. It is the largest terrestrial mammal of which we have any knowledge, and appears to have been a connecting link between the whale and the elephant. The tusks, unlike those of the elephant, were placed in the lower jaw, and curved downwards (see fig. 46), as if intended to be used as a pick to grub up roots, which the short, strong

trunk, with which the creature was evidently furnished could then pull up for food. It reached the length of eighteen feet, was extremely massive in its proportions; it was aquatic in its habits (see fig. 45).

Do'lomite. A crystalline magnesian carbonate of lime, often forming extensive beds. Much of the common white marble is dolomite. It is so named after the French geologist, Dolomieu.

Drift. A term applied by geologists to earth and rocks which have been drifted by water, and deposited over a country while submerged. The Drift period is sometimes called the Boulder period.

Echinoder'mata, Echinoderms (from Greek, echinos, a sea hedge-hog; derma, skin). A class of invertebrate animals with an opaque, leathery, or crustaceous covering, armed with tubercles or spines.

Encri'nite (from Greek, krinon, a lily). An extinct genus of echinoderms. These animals had long jointed stems attached to the rocks and supporting a cup-like calcareous skeleton (see fig. 19), covered by the soft parts of the animal, and containing the viscera; the mouth was in the centre of the cup, and surrounded by numerous and wide-spreading arms. These beautiful creatures abound in the Palæozoic rocks. They were composed of a vast number of parts. Buckland states the number of pieces in one of the species as being one hundred and fifty thousand. They are sometimes found entire, but more frequently in scattered fragments. The detached bones of the stem have received various names, as screw-stones, pully-stones, fairy-stones, and St. Cuthbert's beads.

Eoce'ne (from Greek, eos, dawn; kainos, recent). A name for the Older Tertiary formation, in which the dawn, as it were, of existing species appears. In the Eocene we find about three per cent. of existing shells, which are the test fossils.

Equise'tum (from Latin, equus, a horse; seta, a bristle). A genus of plants.

Errat'ic, wandering. In geology this term is applied to any transported materials on the earth's surface; as, erratic blocks, &c.

Estuary (from Latin, æstus, the tide). The widened mouth of a river, alternately occupied by the waters of the river and of the sea.

Fau'na (from Latin, faunus, the name of a rural deity among the Romans). All the animals which belong to a country constitute the fauna of that country.

Feld'spar, Felspar (from German, feldspath). An important mineral, consisting of silica, alumina, and potash, with traces of lime and often of oxyde of iron. It is one of the essential constituents of granite, gneiss, mica slate, and porphyry, and enters into the composition of most of the igneous rocks. The colors are generally white or fleshy red, occasionally bluish or greenish.

Fet'id (from Latin, fæteo, to have an ill smell). Having an offensive smell.

Fis'sile (from Latin, findo, to split). Easily split.

Fis'sure. A crack; a separation; a long narrow opening.

Flint. A sub-species of quartz, of a yellowish, bluish, or blackish gray color. It is of various forms, and generally contains some foreign substance

as a nucleus; it occurs in detached fragments of various size, which are coated by a calcareous crust. It is very hard, and strikes fire with steel.

Flo'ra (from Latin, Flora, goddess of flowers). All the plants which are native to a country constitute the flora of that country.

Fluor-spar (from Latin, fluo, to flow), (*Fluorid of Calcium*). It commonly appears in masses, but crystallizes in octahedrons, which are frequently changed into cubes. It is a beautiful mineral, much used for making ornamental vessels, for which purpose it was much used by the ancients.

Fluviatile'. Belonging to a river, especially of fresh water.

Fos'sil (from Latin, fodio, to dig). The term fossil is appropriated to those organic substances which have become penetrated by earthy or metallic particles, and are found in rocks or the earth. Thus we say, fossil-shells, fossil-bones, fossil-wood.

Ganöideans (from Greek, ganos, splendor; eidos, resemblance), *Ganoid* fishes. The first order of fishes, according to Agassiz, characterized by angular scales covered by bright enamel (see fig. 17). The bony pike and sturgeon belong to this order.

Gas'teropo'da (from Greek, gaster, belly; pous, foot). The plural of Gasteropod. Mollusks, with the locomotive organs on the under part of the body, as the snail.

Ge'nus (Latin). An assemblage of species, possessing certain characters in common, by which they are distinguished from all others. It is subordinate to class and order, and in some arrangements to tribe and family. A single species, possessing certain peculiar characters which belong to no other species, may also constitute a genus; as the Camelopard and the Flamingo.

Gigan'teum, Gigan'teus (Latin). Gigantic.

Gla'cier (from French). Masses of ice and snow formed in valleys on the sides of the Alps, and other high mountains: these masses are frequently many miles long and wide, and remain undissolved in summer, but, from the granulous nature of their formation, have an insensible but continuous sliding motion, which causes them to advance on the lower and warmer regions, where in summer these advanced portions are melted away. "*The Glacier Theory.*"—The theory that the frigid and temperate zones were covered with ice during the "ice period," and that by the agency of this ice, during its formation and dissolution, the loose materials on the earth's surface (belonging to the Boulder period) were transported and accumulated.

Glyptodon (from Greek, gluptos, sculptured; odous, tooth). An extinct quadruped of the Armadillo family, of the size of an ox, covered with scales, and having fluted teeth (see fig. 48).

Gneiss (from a Saxon word, meaning to sparkle). A rock, resembling granite in its character, being composed of quartz, feldspar, and mica, but as a general thing having less feldspar and more mica than granite. The most marked difference, however, consists in an evidence of stratification, of which there is no trace in granite. Its position is above the granite and below the mica slate, into both of which it insensibly passes. It often contains hornblende, and is rich in metallic ores.

Grap'tolite (from Greek, graptos, written; lithos, stone). A fossil zoophyte. It is found in the Cambrian and Lower Silurian shales, and has received its name from the curious markings it has made on the rocks.

Green'stone. A tough variety of the Trap rocks, of a greenish tint; it consists of hornblende and feldspar.

Gyp'sum. Sulphate of lime, containing two per cent. water. It often occurs in transparent crystals, or crystalline masses, easily splitting into plates, and is then called Selenite. There are many varieties; when white, fine-grained, and translucent, it constitutes alabaster; the coarser kinds, when burnt to drive off the water and ground up, are called Plaster of Paris, which is used in agriculture and the arts.

Heterocer'cal (from Greek, eteros, opposite; kerkos, a tail). An epithet applied to those fishes which have the spine prolonged into the upper lobe of the tail, which is rendered longer than the lower.

Heteroge'neous (from Greek, genos, a kind). Applied to any substance, the component parts of which are unlike, and do not agree with each other; opposed to homogeneous.

Hippopot'amus (from Greek, ippos, a horse; potamos, a river). A pachydermatous animal allied to the elephant. It inhabits nearly the whole of Africa, lives principally in the rivers, though it also feeds on the herbage of the banks. They are large, unwieldy animals, sometimes reaching the length of 17 feet. Several fossil species have been found.

Homocer'cal (from Greek, omos, joined; kerkos, a tail). This term is applied to those fishes into whose tail the spine does not enter. Almost all fishes of the present period are homocercal.

Hye'na (from Latin, hyæna). A quadruped of the genus Canis, having small, naked ears, four toes on each foot, a straight-jointed tail, and erect hair on the neck. It is a solitary carnivorous animal, fierce, cruel, and untamable. The greatest distances from the Equator at which these animals are now found are Asiatic Turkey and the Cape of Good Hope, though their fossil bones are found in great numbers in England and Germany. There are several varieties now existing; that of the Cape most nearly resembles the extinct species.

Hylæosau'rus (from Greek, hylaios, belonging to wood; sauros, lizard). An extinct animal, which blended the peculiarities of the crocodile with those of the lizard. It is found in the Wealden formation of England, and is sometimes called the Weald lizard. Its great peculiarity consists in the large, angular, spinous bones, which are found with the skeletons, and which are supposed to have formed a continuous row inserted in the skin, from the neck to the tail.

Hy'pogene (from Greek, upo, under; ginomai, to be). A term applied to rocks not formed at the surface of the earth, but thrust up from below, and apparently of igneous origin, as granite, gneiss, &c.

Ichthyosau'rus (from Greek, ichthus, a fish; sauros, a lizard). The fish lizard. This genus attained its greatest development in the Lias, where ten species have been found; one was found in the Muschelkalk of Germany. They also occur in the Oolite, and in corresponding strata in North America.

In general outline it is believed to have most resembled the porpoise (see fig. 27); its head was like a lizard's, and its teeth, numerous, conical, and striated, resembling those of the crocodile, were set in an enormous mouth. Its eye was of extraordinary size (see fig. 28), and the sclerotic coat was surrounded by a number of bony plates, which enabled it to adapt its vision to a great variety of distances, as is the case with the tortoise, golden eagle, &c. The extremities, consisting of a number of small, cubical bones, tied together by a ligament, were shortened, and acted as oars; the fore-paddles contained about one hundred bones, the hinder pair, which were smaller, only thirty or forty. They were carnivorous in their habits, and sometimes reached the length of thirty feet.

Ig'neous (from Latin, ignis, fire), belonging to or consisting of fire. The Igneous rocks are those rocks whose structure is attributable to the influence of heat, such as granite and basalt. They are distinct from the stratified rocks, or those formed by deposits from water.

Igua'nodon (from iguana, and the Greek, odous, tooth). An extinct saurian reptile, rivalling the elephant in height, and greatly more than rivalling him in bulk and length. The identity of its very peculiar teeth with those of the Iguana, a South American lizard, and the relative proportion of its bones being the same, some of the greatest geologists, taking that animal as a guide, estimated its length as seventy feet, even that being a considerable reduction of the result of the fully carried out proportion: others have lowered the estimate to thirty feet; whatever its length, the size of the leg bones gives the hind limbs an elevation of more than nine feet. Neither skull nor jaws have yet been found, but its teeth prove it to have been herbivorous; they were wonderfully adapted to cutting the tough vegetation which covered the earth at the period of its existence. This creature with its congeners, the Hylæosaurus and Megalosaurus, belong to the Weald formation, though it seems to have been continued to the earlier periods of the Cretaceous age.

Infiltra'tion. The act or process of entering the pores or cavities of a body. The substance which has entered the pores of another body—as calcareous infiltration, &c.

Infuso'ria (from Latin, infundo, to pour in). A class of microscopic animalcules, which have received their name from the fact that they abound in infusions of vegetable matter.

Jet. A variety of coal of very hard, fine texture, glossy, black, and susceptible of a beautiful polish. All the varieties of coal, as anthracite and bituminous coal, jet and lignite or brown coal, owe their peculiarities in all probability more to the mode in which they have been mineralized than to the nature of the plants from which they were formed.

Kan'garoo. A singular animal found in New Holland, resembling in some respects the opossum. It has a small head, neck, and shoulders, and the body increases rapidly in thickness towards the hinder parts. The fore legs are short and small, useless in walking, but well adapted for digging and conveying food to the mouth. The hind legs and tail are long and very powerful; the animal moves by leaps.

Lacus'trine, Lacus'tral (from Latin, lacus, a lake). Belonging to lakes or swamps.

Lepidoden'dron (from Greek, lepis, scale; dendron, a tree). This fossil tree was so called from the scaly appearance of its bark, which was caused by the fall of its leaf stalks. These scars are so regular and beautiful in their forms that the fossil looks like a beautiful piece of sculpture. The Lepidodendra are considered as belonging to the Lycopodiacea or club mosses, or more properly as having been a connecting link between these and the Conifera. Their great size, rising to sixty or seventy feet, and being several feet in diameter, rendered a strengthening process necessary, and this process assimilated their internal structure to the Conifera. They are among the most numerous fossils of the coal measures.

Lig'nite (from Latin, lignum, wood). Wood partially converted into coal.

Loam. A mixture of sand and clay.

Lycopo'diacea (from Greek, lucos, a wolf; pous, foot). A family of moss-like plants, but which differ materially from the true mosses; they are sometimes called club-mosses.

Magne'sia. A primitive earth, having for its base a metallic substance called Magnesium. Magnesia is a soft, white powder, without taste or smell. It is seldom found pure.

Mam'mal. Any animal that is suckled when young.

Mamma'lia (from Latin, mamma, breast). The class of animals which comprehends those which suckle their young; they are vertebrated, have warm red blood, and a double system of circulation.

Man'ganese. A metal of a dusky white, or whitish gray color, very hard and difficult to fuse. It never occurs as a natural production in a metallic state. The substance usually so called is an Oxide of Manganese, but is not pure.

Marl. A mixture of lime and clay. There are several varieties of marl. It is much used by agriculturists as a manure.

Marsu'pials (from Latin, marsupium, pouch). Animals having a pouch, or bag, for carrying their young—as the Kangaroo and Opossum.

Mas'todon (from Greek, mastos, a nipple; odous, a tooth). A genus of extinct mammals allied to the elephant (see fig. 45).

Megathe'rium (from Greek, megas, great; therion, beast). The Megatherium was allied to the Sloth and Armadillo, but exceeded them in size to a greater degree than any other fossil animal exceeds its living congeners; the largest of the existing species not exceeding the dimensions of an ordinary sized dog, while this creature reached the length of twelve, the height of eight, and, at the hips, the breadth of five feet. The massiveness of its structure is even more striking than its great size, the thickness of the femur (thigh bone), being made nearly to half its length, the pelvis (hip bone) extraordinarily wide and strong, and the tail, which was long, was made up of numerous vertebræ, of great size, the largest being seven inches in diameter, giving, in all probability, a circumference to the tail of six feet at its thickest part. The hind foot a yard long, had nearly half its length in the heel bone, which had a circumference of twenty-eight inches. These preparations for supporting the weight of the animal indicate some peculiarity of habits which they were to meet; and when we turn to the head, and find it furnished with teeth eminently adapted for cutting vege-

table productions, and examine the fore-legs, and see, that where attached to the trunk there is a clavicle (collar bone), not possessed by any other of the large ruminating animals, resembling that of the human being, which admits of a rotary motion, showing that some other office than that of mere locomotion was demanded of the limbs, and that the long fore-feet terminated in powerful claws, set, like those of the mole, obliquely to the ground, we see a structure eminently adapted to digging up roots, and undermining the strong succulent vegetable giants of the hot regions it inhabited. The powerful hind-quarters, with the aid of the large tail and one fore-foot, could readily support the weight, and leave the other foot free to dig. The creature was cased, body and tail, in bony armor, varying in thickness from three-fourths of an inch to an inch and a half. The weight of this must have been very great, but it formed a protection from insects, dirt, and dust, to which its habits greatly exposed it, and also defended from more active and carnivorous animals its unwieldy slow-moving body. The remains of this animal (see fig. 49) have as yet only been found in the Tertiary beds of the Pampas of South America, where their bones have been found through a region of country more than six hundred miles in extent, and in similar deposits in Georgia, North America.

Mei'ocene (from Greek, meion, less; kainos, recent). A name for the second division of the Tertiary, intended to indicate that though the number of still existing shells had increased since the Eocene period, they were still in the minority, being about seventeen per cent.

Metallif'erous. Containing metal.

Metamor'phic (from Greek, meta, change; morphe, form). In geology it relates to the changes minerals and rocks have undergone since their deposition. Those sedimentary rocks which are supposed to have been altered by the action of heat are called Metamorphic rocks.

Mi'ca (from Latin, mico, to shine; mica, a grain or particle). A mineral susceptible of being cleaved into elastic plates of extreme thinness. It is either colorless, or presents some shade of light brown, gray, smoky brown, black, and occasionally, green or violet. It is generally translucent, and is used instead of glass for lanterns and for the doors of stoves, as it is not brittle like glass.

Mollus'ca (from Latin, mollis, soft). The name of the second branch of the animal kingdom, comprising species whose bodies are soft and inarticulate. Some of them are naked, while others are covered by a shell. With the exception of a single family, they have no distinct organ of sense, except eyes, and even these are wanting in some species. This division includes the snail and oyster, and the whole class of shell animals, together with the cuttle-fish and ascidiæ.

Mol'lusk. One of the Mollusca.

Monocotyl'edon (from Greek, monos, one; kotuledon, seed lobe). A plant whose seeds have but one seed lobe.

Mo'nocoty'ledons. A class of plants having but one seed lobe in the embryo.

Monocotyle'donous. Having but one seed lobe. A class of plants.

Mo'raine (French). A term applied to lines of blocks and gravel, extend-

ing along the sides of separate glaciers, and along the middle part of glaciers formed by the union of one or more separate ones.

Muschelkalk' (from German, muschel, a shell; kalk, lime). A German name for a shell limestone, whose strata belong to the New Red Sandstone formation.

Mylo'don (from Greek, mulo, a mill; odous, a tooth). An extinct family of the order Edentata (without teeth), so called from the absence of incisor teeth. The Sloths, Ant-eaters, and Armadilloes are existing examples. The Mylodon was allied to the Megatherium, but more closely resembled the Sloth. The length of a perfect skeleton found near Buenos Ayres is eleven feet, including the tail, which was the same length as the hind-legs (see fig. 50). Like the Megatherium it was broad and massive, with very large feet, and was a vegetable eater. Prof. Owen supposes that its peculiar structure adapted it first for digging around trees, and then, resting on the tripod base of its hind-legs and tail, that it seized the trunk with its fore-legs and rocked it to and fro, till it prostrated it, when it devoured the leaves and tender parts. The Scelidotherium, also allied to the Megatherium, was still more peculiar as to the disproportion between the fore and hind quarters which characterizes these animals: while the length of the creature was not greater than that of a Newfoundland dog, the hinder parts were as ponderous as those of the hippopotamus. All these animals are called Megatharoids, and are found in the Pampas of South America, and the Tertiaries of Georgia, United States.

Nau'tilus (Latin, nauta, a sailor). The name of a small genus of Cephalopodous Mollusca. The animal has the sack, eyes, parrot beak, and funnel, of the other Cephalopods, but its mouth, instead of the large arms and feet, is surrounded by several circles of numerous small tentacles without cups. The shell is a spiral, symmetrical, and chambered shell, that is, divided by numerous partitions, which are traversed by a tube, which passes from the outer cavity occupied by the animal, and by which it is supposed to increase or lessen its weight, by introducing or expelling the sea water, and thus rise or sink at pleasure. This family has but one living representative, which must not be confounded with the Argonauta Argo, frequently, but improperly, called Nautilus; but there are one hundred and twelve fossil species. They appear to have been introduced in the Devonian period, and to have reached their maximum in the Carboniferous era.

Nod'ule (from Latin, nodus, a knot). A rounded mineral mass of irregular shape.

Nu'cleus (from Latin, nux, a nut). A kernel. A centre round which matter has accumulated.

Nummulite' (from Latin, nummus, money; and from Greek, lithos, stone). Fossil money. An extinct genus of Cephalopods, of a flattened form like a small coin, divided internally into small chambers. Nummulite limestone, which in some places is abundant, receives its name from being principally composed of these shells. They were very abundant in the Cretaceous age.

Obsid'ian. Named after Obsidius, a glassy kind of lava. Volcanic glass.

Oo'lite (from Greek, oon, an egg; lithos, stone). A granular variety of

limestone, frequently called roe-stone, from its resemblance to the roe of a fish. It sometimes constitutes extensive beds, and gives its name to all the strata intervening between the Lias and the Wealden.

Or'der. An arrangement or disposition. A division of natural objects, generally intermediate between class and genus.

Organ'ic. Relating to an organ. Organic remains are the fossil remains of organized beings.

Oss'eous (from Latin, os, bone). Bony; composed of bone. Osseous breccia is any cemented mass of fragments of bones of animals, extinct and otherwise, found in caverns and fissures.

Pachy'derms, Pa'chyder'mata, (from Greek, pachus, thick; derma, skin). An order of quadrupeds, including the elephant, horse, pig, &c., distinguished by the thickness of their hides.

Palæontol'ogy (from Greek, palaios, ancient; on, a creature; logos, a discourse). That branch of zoology which treats of the fossil remains of plants and animals.

Palæothe'rium (from Greek, palaios, ancient; therion, beast). This animal (see fig. 45) belongs to the order Pachydermata (thick-skinned animals), between the living genera of which there are greater spaces than between those of any other order of Mammalia. This order appears to have been much more numerous in the Tertiary ages, when it was introduced, than at present, and from the extinct genera and species we are able to fill many of the breaks in the present system. This genus, with the Anoplotherium (see fig. 44), Lophiodon, Anthrocotherium, Cheropotamus, and Adapis, closely allied to it, were first found in the great Paris basin, and belong to the earlier Tertiary or Eocene period; their relics have been found in various parts of the earth. The nearest approach among living animals, to the appearance of these extinct aquatic quadrupeds, is found in the Tapirs, which abound in South America; and are also found in Malacca, Sumatra, and some parts of Africa. The Palæotherium seems intermediate between the rhinoceros, the horse, and tapir. Seven species have been found in the Lacustrine Eocene beds of Paris and the Isle of Wight, and five in similar beds of the Meiocene, at Sansan, in France. The bones of the nose show that, like the Tapir, they had a short, fleshy trunk. The Anoplotherium is described elsewhere (see Ano). This genus is in some respects intermediate between the horse and rhinoceros, and in others between the hippopotamus, the hog, and the camel. The Lophiodon is allied most nearly to the tapir, rhinoceros, and hippopotamus; fifteen species have been distinguished. The Anthrocotherium, so called from having been discovered in the Tertiary coal or lignite in Liguria, was allied to the hog and hippopotamus. Seven species have been discovered varying in size between the two animals mentioned. The Cheropotamus resembled a hog more closely than any of the preceding. The Adapis was most like a hedgehog, though three times its size. It seems to be a link between the Pachydermata and the Insectivorous Carnivora.

Palæozo'ic (from Greek, palaios, ancient; zoe, life). Relating to ancient life; belonging or relating to fossils.

Palm. Name of a family of plants, embracing many living and extinct

species. The Palms are monocotyledonous, have a straight, unbranching, cylindrical stem, terminating in a crown of leaves, from the middle of which spring the flowers and fruit. All the living Palms are natives of very warm climates, though the fossil Palms are found within the arctic regions. They vary in height from two to a hundred feet.

Pal'mate, Pal'mated (from Latin, palma, palm). Resembling a hand with the fingers spread; as palmated leaves; or the webbed feet of aquatic birds, which are called palmated feet.

Pampas. The name given to vast prairies in the central part of South America, near Buenos Ayres.

Peperi'no (Italian). A volcanic rock, formed by volcanic cinders, sand, &c., cemented together.

Petrifac'tion (from Latin, petra, a stone; facio, to make). The conversion of any animal or vegetable substance into stone, or a body of stony hardness. This is effected by the gradual displacement of the particles of the body said to be petrified, and the infiltration of silicious particles or lime in combination with iron or iron pyrites in their stead. Petrifaction is also any organized body rendered hard by the deposition of stony matter in its cavities. Bodies that are simply incrusted by stony matter are frequently, but incorrectly, called petrifactions. Petrifaction is supposed in some cases to have been a very rapid process.

Pet'rified. Changed into stone. Having undergone petrifaction.

Placoi'deans (from Greek, plax, a broad plate; eidos, resemblance). The first order of fishes in the arrangement of Agassiz, having the skin covered with enamelled plates, as the shark, ray, lamprey, &c. (See fig. 17.)

Plei'ocene, Plio'cene (from Greek, pleion, more; kainos, recent). A term applied to the newer Tertiary deposits, a majority of whose shells belong to existing species.

Pleist'ocene (from Greek, pleistos, most; kainos, recent). The name of the latest Tertiary formation, which contains ninety-five per cent. of existing shells.

Plesiosau'rus (from Greek, plesion, near; sauros, lizard). A genus of extinct marine animals, allied to the lizard and crocodile. The head was lizard-like, and connected by a long and slender neck to a short body, which terminated in a tail like a crocodile (see fig. 29). The paddles resembled those of the Ichthyosaurus, but were longer and in some degree compensated for the short body and a tail that could have given little aid in swimming. Altogether the creature's peculiarities indicate a mode of life confined to shallow water and principally spent on its surface, where the long neck, composed of more vertebræ than that of the swan, and probably like the swan's arched over its back, could seize prey from a considerable distance. The first appearance of this creature is in the Trias, but they reached their greatest development in the Liassic period; ten species having been taken from those beds; several others have been found in the higher stages of the Oolite, and the Chalk of New Jersey.

Poi'kilitic (from Greek, poikilos, variegated). The name given to the formation which lies below the Lias, and above the Permian, on account of the variety of tints which pervade its sandstones and marls. It is also called Trias, New Red Sandstone, and Saliferous system.

Pol'yp (from Greek, polus, many; pous, foot). The Polyp is an animal of the Radiate class, with, in general, a cylindrical body or sac, at one extremity of which there is a mouth surrounded by arms or tentacles. They live in communities; the separate animal is called a Polyp, the mass is termed a Zoophyte. They are generally rooted by a calcareous base, and the stony mass which they form is called the Polyparium. In fossils, the Polyparium is all that remains, being in reality the skeleton of the animal, not its work or residence, but an internal secretion of its living body, and, being very durable, when the animal dies this calcareous skeleton remains, and serves as a base to support a new creature. In this way masses of rocks, leagues in extent, are formed; and these, separately insignificant animals, by their united action, produce most important changes on the surface of the globe. They propagate rapidly, and, when living, their fleshy substance and spreading tentacles of various colors, overspreading the calcareous foundation, are said to render the tropical oceans scenes of great beauty.

Por'phyry (from Greek, porphura, purple). Originally applied to a red rock found in Egypt. A rock consisting of a compact feldspathic base, through which are scattered crystals of feldspar of various colors, sometimes white. When polished these crystals present a beautiful appearance. There are red, purple, green, and bluish varieties, which are highly esteemed as marbles. The term Porphyry is now frequently applied to any rock of compact, uniform base, which contains crystals of another mineral. Porphyry belongs to the Igneous or unstratified class of rocks.

Pozzuola'na, Pozzola'na. Volcanic ashes which are exported from Pozzuoli, a town near Naples. They form a valuable mortar, which *sets* or hardens under water.

Precipita'tion. The action by which a body abandons a liquid in which it is dissolved or suspended, and becomes deposited at the bottom.

Precipita'ted. Cast or thrown down.

Pterodact'yle (from Greek, pteron, a wing; daktulos, a finger). This creature made its appearance in the Lias, and extends its range to the Wealden; they were most abundant about the middle of the Oolitic series. This genus differed from all others, whether living or extinct, in the structure of their anterior extremities, which served both as feet and wings, and fitted them equally to cling to trees, or soar through the air in pursuit of the insects, which seem to have been their favorite food. In external form they somewhat resemble the modern bats (see fig. 30), being a connecting link between birds, bats, and lizards. The form of the head and length of the neck resembled birds, the wings approached to those of bats, and the body and tail remind one of the ordinary Mammalia. The small reptilian skull and beak, set with not less than sixty sharp-pointed conical teeth, complete the combination of apparent anomalies. The eyes were of enormous size, probably fitting them to seek food at night; none of these animals possessed a large body, but the sweep of the wings was great. There is but one genus, though seventeen species have been discovered.

Pum'ice (from Latin, spuma, foam). A substance frequently ejected from volcanoes, very light and porous, but equally hard and rough. It is of various shades, from nearly white to a reddish brown or black. It appears to consist of parallel fibres, owing to the extreme minuteness of the elon-

gated cells; these cells are probably produced by the disengagement of gases when the lava is in a plastic state. Pumice is of three kinds: glassy, common, and porphyritic.

Ra'diate (from Latin, radius, a spoke). One of the four great divisions in which Cuvier arranged the animal kingdom; it includes all those animals whose organs of sense and motion are arranged round an axis, and on one or several radii, or on one or several lines extending from one pole to the other. This division comprehends the Echinodermata, the Entozoa, the Acalepha, the Polypi or Polypods, and the Infusoria. Radiate animals are of the lowest order of organization in the animal kingdom.

Rep'tile (from Latin, repere, to crawl). A term applied to any animal that moves naturally on its belly, or on very short legs, as serpents, lizards, tortoises, &c. Reptiles or Reptilia constitute a class of animals which are cold-blooded, vertebrated, and breathe air. The Batrachians (frogs) are by some separated from this class, because in the tadpole state they breathe water.

Rhino'ceros (from Greek, rin, rinos, a nose; keras, a horn). A genus of large-sized Pachyderms, allied to the elephant, hippopotamus, tapir, &c. Naturalists describe five living species; two of them have a single horn on the nose, and three have two horns. There are several fossil species.

Ru'minantia. An order of herbivorous animals, having four stomachs, the first so situated as to receive a large quantity of vegetable matter, coarsely bruised by a first mastication, which passes into the second, where it is moistened and formed into little pellets, which the animal has the power of bringing again to the mouth to be rechewed, after which it is swallowed into the third stomach, from which it passes to the fourth, where it is finally digested. The camel, the deer, the ox, the goat, and the sheep are examples of this order. The ruminating animals were among the latest introduced.

Sal'amander. The popular name of a genus of reptiles, intermediate between lizards and frogs.

Salif'erous. Producing or bearing salt. The New Red Sandstone, Trias or Poikilitic formation, is also called the Saliferous formation, because rock salt is abundantly found in some of its strata in Europe.

Sau'ria (from Greek, sauros, a lizard). An order of reptiles with long scaly bodies and long tails, comprising lizards, alligators, &c.

Saurŏid' (from Greek, sauros, lizard; eidos, resemblance). Resembling a lizard, as the sauroid fishes of the earlier formations.

Scelidothe'rium (from Greek, scelidos, thigh; therion, beast). See *Mylodon.*

Sco'ria. Volcanic ashes; cellular, slaggy lava, thrown from a volcano.

Sedimen'tary. Consisting of matter that has settled down or subsided. Sedimentary rocks have been formed by the deposition of materials suspended in water, and hardened, either by the pressure of masses resting on them or by the action of heat.

Septa'ria (from Latin, septa, partitions). The plural of Septarium. A name given to round nodules of clay or marl (see figs. 39, 40.) These nodules are sometimes entire, more frequently intersected by cracks or fissures, which have been afterwards filled by the infiltration of mineral matter.

Ser'pentine. A species of Magnesian stone, usually of a dusky green, and shaded or mottled like a serpent's back. This rock is generally unstratified, and nearly allied to the harder varieties of steatite and pot stone. There are two varieties, the common and the precious.

Shale. A fine-grained clay rock, having a slaty structure.

Sil'ica (Latin, silex, flint). Silicious earth—the Oxide of Silicon (the elementary base of Silica). It combines with many of the metallic oxides, and is sometimes called silicic acid. Rock crystal, quartz, and flint, are nearly pure silica or silex.

Sil'icate. A compound of silicic acid and a base. Plate and window glass are silicates of soda and potassa; flint glass is the same compound with a large addition of silicate of lead.

Sili'cified. Petrified or mineralized by silex.

Sili'cious. Pertaining to Silica, or partaking of its qualities.

Sivathe'rium (from Siva, a Hindoo god, and therion, beast). The remains of this animal are found in the Tertiary deposits, on the flanks of the Sub-Himalayas or Sewalik Hills of India. It constitutes a connecting link between the Ruminantia and Pachydermata. The short thick head of the animal had a skull approaching in size to that of the elephant; the posterior part is greatly developed, and presents cellular protuberances like those of the elephant (see fig. 48). It had two pair of horns: the front and smaller pair were just above and between the orbits of the eyes; the hinder pair, probably palmated, were set far back on the head. The form of the nasal bones indicates a trunk or proboscis, an organ unknown among all living ruminants. This creature, when living, probably bore some resemblance to an enormous gnu or antelope.

Sloth (from Saxon, slaw, slow). The name of a genus of tardigrade edentate animals. They are so called from the slowness of their motions; they are natives of South America, where at present there are but two small species, but where, in bygone epochs, many gigantic varieties existed, whose fossil remains are found in the Pampas and caves of the middle and southern portions of the continent. They are vegetable eaters.

So'da. The protoxide of Sodium. It is sometimes called a mineral alkali; it is also called a fixed alkali, in contradistinction from Ammonia, which is a volatile alkali.

Spe'cies. A subdivision of a genus. All individuals that have a perfect resemblance to each other, in all the important qualities of their nature, and are capable of the invariable continuance of the same, from generation to generation, constitute a species. Those variations which are produced by accidental causes, and which are not capable of an invariable continuance, mark what are called varieties.

Specif'ic. Relating or belonging to species.

Spheroi'dal, having the form of a Spheroid. A Spheroid is a body which approaches to the form of a sphere, but is not perfectly globular; the earth is an oblate spheroid, that is, flattened at the poles; formerly it was supposed by some astronomers to be a prolate or oval spheroid. In crystallography any crystal bounded by several convex sides is called spheroidal or spheroidic.

Stal'actite (from Greek, stalasso, to drop). A pendent cone of carbonate

of lime, attached like an icicle to the top or sides of a cavern. It is caused by the slow dripping of water impregnated with carbonate of lime, which is deposited as the water passes. The term stalactite is also applied to any mineral taking the same form.

Stal'agmite. A mineral deposit of the same nature and origin as the Stalactite, but formed on the floors of calcareous caves, and therefore ascending as it forms, not descending, as the Stalactite does.

Stratifica'tion. An arrangement in beds or layers.

Stri'a (Latin), in the plural *Striæ.* A very narrow channel or thread-like crease, in any hard substance, as a shell or a rock.

Superfi'cial. Being on the surface—not penetrating the substance. The modern deposits are termed the superficial deposits.

Sy'enite, Sienite. A species of granite, deriving its name from Syene, in Upper Egypt. It consists of quartz, hornblende, and feldspar; it differs from ordinary granite in the absence of mica, and is an exceedingly durable stone.

Ta'pir. The name of a genus of pachydermatous quadrupeds found in South America and Sumatra. They are intermediate between the rhinoceros and hog, much smaller than the former.

Terebra'tula (Latin, terebro, to bore). A genus of bivalve mollusks of the class Brachiopoda. One of the valves has a hole for the passage of a fleshy ligament by which the animal attaches itself to submarine bodies. Some living terebratulæ are found in the South Seas; but they abound as fossils. They are among the oldest fossils found, and have been continued through the succeeding formations.

Terres'trial (Latin, terra, the earth). Belonging to, or existing on the earth, as, terrestrial animals.

Tor'toise (from Latin, tortus, twisted). An animal of the order Chelonia, covered by a shell above and below, between which they have the power to withdraw their head and short legs. There are many living species belonging to the land, to the ocean, and to fresh water. They are in general called Turtles. The foot-prints of Chelonians are found in the Triassic strata, though their bones have not been found earlier than the Oolite, and they have lived in all the subsequent periods. They have attained their greatest development in the present age.

Tox'odon (from Greek, toxon, a bow; odous, a tooth). A gigantic Pachyderm, distinguished by the singular shape of its gnawing teeth, which are bent like a bow. Their remains, with those of other enormous animals, have been found in the Pampas of South America.

Tra'chyte (from Greek, trachus, rough). A species of lava in which feldspar predominates; it also contains hornblende and mica. When the feldspar crystals are thickly and uniformly disseminated through the mass it is called Trachytic Porphyry.

Trap (from Swedish, trappa, stairs). A heavy dark-colored Igneous rock, composed of feldspar, augite, and hornblende. There are many varieties of Trap. It usually presents itself in columnar or globular masses, and frequently in a succession of tabular elevations, from which appearance it has derived its name.

Tra'vertine (from Italian, travertino). A white concretionary limestone,

usually semi-crystalline, deposited from water holding carbonate of lime in solution. It is found at the Sweet Springs of Virginia, the Hot Springs of Arkansas, and many other places.

Tri'lobite (from Latin, tres, three; lobus, lobe). An extinct family of Crustacea. This creature, whose remains have come down to us in vast numbers, was introduced in the Silurian period, and rapidly increased so as to form one of the most important features of the Palæontology of the different strata, both as to the number of the species and of the individuals, until the Carboniferous period, when, about the time of the mountain limestone, they seem to have disappeared altogether. Their compound eyes (see fig. 21) have been found in a state of perfect preservation, and prove that the waters of the oceans they inhabited were clear enough for vision; and that the same relation between the eye and light existed in those far-gone ages as in our own times. The body of the animal was divided by two deep parallel grooves into three apparent lobes, from which its name (see fig. 20). It probably had the power of curling itself round as the wood-louse does, and covering up its softer parts when attacked. It either had no feet, or they existed in so soft and rudimentary a form that they perished soon after the death of the animal, for no indications of feet or antennæ have ever been found.

Turtle. See *Tortoise.*

Type (from Latin, typus, to impress). An emblem that represents something else. In natural history, that which combines most clearly the distinctive characters of a group may be taken as its type or representative; thus a particular individual may be a type of a species; a certain species the type of a genus, &c.

Vertebra'ta. Animals having a spine with joints. This is the highest of the four divisions of the animal kingdom. Vertebrated animals include mammals, birds, reptiles, and fishes.

Ver'tebrate. Having vertebræ or a spine.

Ver'tical. Directly over head.

Volute'. An architectural ornament resembling a spiral scroll, and forming an important part of the capitals of pillars. There is a genus of Mollusks called Voluta, from their spiral shells.

Wealden. A term applied, in England, to certain strata above the Oolite.

Za'mia (from Greek, zemia, loss or damage). A genus of plants possessing nearly equal affinities with palms and tree ferns, and bearing heads of flowers like pine cones; fifteen species have been found in the Oolite and Lias.

Zinc. A metal of a brilliant white color, with a shade of blue, and appearing as if composed of plates adhering together. It is not brittle, but is less malleable than copper, lead, or tin. When heated it can be rolled into sheets.

Zo'ophyte (from Greek, zöon, an animal; phuton, plant). Animals which partake in some degree of the characteristics of plants are called Zoophytes. Sometimes a single animal of Polyp is called a Zoophyte, in other cases, where many live together, the term is only applied to the compound structure, as with the corals. They often beside the fixed base have the branching form of vegetation, and the polyps resemble flowers.

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